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ABSTRACT

The findings and recommendations of the United States Education and Instruction through Telecommunications (USE IT) project are presented. USE IT assessed the relationship of distance learning to the nation's educational needs, especially its role in achieving the National Education Goals. USE IT examined all levels of education, prekindergarten through adult continuing education and worker training. Issues critical to any distance learning planning and implementation are addressed: access to learning technologies; training and outreach; partnerships between public and private sectors; statewide and multistate technology applications; and federal action for distance learning. This report is designed to inform decisions on local and state distance learning strategies and to help shape the use of the National Information Infrastructure (NII). Two distinct trends form the backdrop: (1) the confluence of three major forces that are shaping society--information and telecommunications technologies, a globally competitive economy, and the changing needs of the workplace; and (2) an unprecedented, decade-long commitment to education reform that seeks to move America from being "a nation at risk" to being a model of world-class education. Telecommunications technologies, their advantages and disadvantages are discussed: broadcasting; satellites; cable; telephone; microwave/Instructional Television Fixed Services (ITFS); wireless; and computer networking. Barriers to information technology use in distance education are examined: incompatibility of technical systems; insufficient use of available resources; costs of technology; regulatory barriers; training people to use distance-learning technologies; course accreditation; cost and accounting systems; institutional structures; programming quality; and awareness and acceptance. Policy issues and strategies to better provide education services using telecommunications and learning technologies for distance learning are reviewed. Appendices include: abbreviations; related reports and studies; federal and state agency contacts; and a glossary of terms. Twenty-seven individuals are listed as resources. (Contains 83 references.) (Author/MAS)

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UNITED STATES

EDUCATION AND INSTRUCTION

THROUGH TELECOMMUNICATIONS

Report prepared under cooperative agreement for The National Telecommunications and Information Administration (NTIA) of the United States Department of Commerce by the Council of Chief State School Officers

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The Council of Chief State School Officers is a nationwide, nonprofit organization of the 57 public officials who head departments of elementary and secondary education in every state, the District of Columbia, the Department of Defense Dependents Schools, and the five extra-state jurisdictions of American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and the Virgin Islands. Through its structure of committees and task forces, the Council responds to a broad range of concerns about education and provides leadership on major education issues.

CCSSO is committed to supporting the effective use of technology to improve learning, provide new opportunities for collaboration and professional development among educators, and extend opportunities for lifelong learning to all Americans. The Learning Technologies program assists states through a network of state technology representatives (STRs), individuals appointed by the chief state school officers. The Council hosts forums on major issues concerning new developments and applications of technology. It also monitors federal regulatory activity affecting telecommunications and education.

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Contents

4 Foreword

6 Executive Summary

13 Introduction

16 Distance Learning and the National Education Goals

22 Distance Learning Resources

51 Challenges and Barriers

59 Recommendations

63 References and Resources

67 Appendices:

67 A. Abbreviations

69 B. Related Reports and Studies

71 C. Federal and State Agency Contacts

91 D. Glossary

Extraordinary changes have taken place since the U.S. Department of Commerce invited applicants for this study in 1992. Unprecedented federal education initiatives in the 103rd Congress have set clear goals for an educated, productive nation and provide the momentum to achieve them. Changes in telecommunications policy and regulation have attempted to address the accelerating potential of information and communication technologies. Private corporations, public organizations, and the communications industry have begun the process of linking homes, schools, and businesses to the developing National Information Infrastructure (NII). Taken together, these developments offer the potential for telecommunications technologies to provide Americans with accessible and affordable lifelong learning.

Many of the policies and priorities we might have recommended at the beginning of this study of education and telecommunications are now in place. For example, while this project was underway, coordination of federal learning-technology programs has begun under the direction of the Committee on Education and Training, with the leadership of the Office of Science and Technology Policy. In the 103rd Congress, bipartisan majorities passed nine education bills, including the Goals 2000: Educate America Act, the School to Work Opportunities Act, and the Improving America's School Act, with new visions for technology. Title III of the Improving America's School Act, the Technology for Education Act of 1994, is the first comprehensive learning-technology act ever passed at the federal level.

President Clinton's Administration initiatives for the NII are providing major policy advances for distance learning and technology applications in education. The Administration's efforts in this area are stimulating commitment of private-sector resources and developing public access through schools, libraries, and hospitals. In addition, these efforts are stimulating review of copyright laws and redefinition of universal access to the nation's telecommunications resources. Federal and state regulatory agencies are considering a wide range of new options that will affect the uses of these resources in schools, homes, and workplaces.

Distance learning is an important component of educational technology use aimed at meeting the National Education Goals. This report addresses the following issues critical to any distance learning planning and implementation:

- **Access to Learning Technologies.** For the 21st century, distance learning is essential to assure Americans of all ages the opportunity to prepare for their economic well being and civic responsibilities. Personal access to technology and distance learning for all learners must be at the center of any technology plan. This report highlights the ways in which distance-learning resources enhance current education opportunities; provide access to learning not available before; and assure learners access to the NII from their homes, education institutions, libraries, and workplaces.

- Training and Outreach. Effective use of any technology requires training for educators as an integral and continuing part of any technology plan. The report illustrates how training activities have been incorporated into distance-learning programs, and emphasizes the potential for these same technologies to provide educators with the means for their professional development and powerful means of interactive collaboration.
- Partnerships Between the Public and Private Sectors. The provision of distance learning requires joint decisions and actions-of private providers and governmental entities. Success depends on the quality of these partnerships. New partnerships are needed, especially to link learning and education institutions and the workplace. The report illustrates how school districts, community colleges, universities, and businesses are working together to share resources, infrastructures, and talents through distance learning.
- Statewide and Multistate Technology Applications. State education and telecommunications laws, programs, and regulations shape the use of distance learning. The report emphasizes effective applications of technologies that provide economies of scale through state, regional, and national actions to work with the telecommunications industry for affordable rates and services.
- Federal Action for Distance Learning. Three types of federal actions are included in this report: first, provision of funds to develop distance-learning facilities and services; second, support for distance learning and technology planning; and, third, the unique importance of federal statute and regulation of telecommunications use and costs and their effects on education.

If our nation is to meet the National Education Goals, we must ably use the potential of distance learning. The challenge is how best to use the resources for specific local and state strategies. This report is designed to inform decisions on these strategies and to help shape use of the NII. Every learner in America—from a classroom in Brooklyn, New York; to an office in Detroit, Michigan; to a community college in Truth or Consequences, New Mexico; or to a ranch in Wyoming—can have access to opportunities to achieve the National Goals through wise use of telecommunications and distance learning.

America's first National Education Goals, backed with standards for high student performance, set the pace and direction for education reform. The developments in distance learning and the promise for its future offer a reality for achieving the Goals. The technology in our homes and workplaces must become a reality in our institutions and services of learning. We offer this study and report as a guide for using the potential for distance learning to help achieve the Goals.

Gordon M. Ambach

THE CONTEXT FOR THIS REPORT

Purpose

This report presents the findings and recommendations of the United States Education and Instruction through Telecommunications (USE IT) project. Begun in January 1993, USE IT assessed the relationship of distance learning to the nation's educational needs, especially its role in achieving the National Education Goals. USE IT examined all levels of education, prekindergarten through adult continuing education and worker training. The working definition of distance learning used in this report is "the delivery of video, voice, or text instruction or information to a learner over distance, from one location to another, using some form of telecommunications technology."

Operating Premises

USE IT has been conducted on the following premises, derived from an extensive analysis and evaluation of the literature on how technology is used in education:

1. The objectives for learners, as included in the National Education Goals, determine how technology is applied to learning and teaching.
2. Distance learning offers great promise in providing educational services, chiefly because information and telecommunications technology provide access to instruction and content that students at all levels could not otherwise have.
3. Distance-learning technologies increase learning effectiveness by offering diverse interactions ranging from "one to many" to "many to many" for learning.
4. Distance learning is a source of cost-effective professional development for teachers and school administrators.
5. Distance learning enables schools to use the most effective teachers available in a given subject area, without geographic limitations.
6. Changes in information technology are having a powerful effect on how those technologies are being designed and used in education.
7. Developments in telecommunications and distance-learning policy and operations for education are closely related to developments in general telecommunications policy.
8. Initiatives, support, and direction for telecommunications policy, operations, and financing will come from both public and private sectors.

DISTANCE LEARNING AND THE NATIONAL EDUCATION GOALS

Two distinct trends form the backdrop of this report: (1) the confluence of three major forces that are shaping our society—information and telecommunications technologies, a globally competitive economy, and the changing needs of the workplace—and (2) an unprecedented, decade-long commitment to education reform that seeks to move America from being "a nation at risk" to being a model of world-class education.

The National Education Goals and the benchmarking legislation designed to help achieve them (e.g., the Goals 2000: Educate America Act, the Improving America's Schools Act, and the School to Work Opportunities Act) will help to orient students to the new world of work and learning. The tools of telecommunication and distance learning, including broadcast, cable, satellite, and telephone networks, have a vital role to play in education reform and in meeting the needs of all learners. New digital interactive systems have emerged that significantly influence learning and teaching. These technologies can serve all learners, regardless of age, disability or language. These tools are already being brought together in a National Information Infrastructure (NII) that provides students with improved access to full voice, video, and data services. According to a recent survey, Americans rank education and instruction as the most important benefits to be gleaned from the NII.

Specifically, distance learning provides the following educational advantages that can contribute to achieving the National Education Goals:

- Distance learning offers a broad range of technologies to serve a variety of educational functions.
- Distance learning continues to serve such tra-

ditional functions as providing instruction to learners at remote sites and instruction in subject matter not readily available. A recent survey of small, rural school districts found that half of them use distance learning.

- Distance learning will be increasingly helpful in improving instructional practices through such offerings as electronic field trips and visits to other resource-rich environments.
- Distance learning is uniquely able to connect school-based learning to its applications in the workplace through electronic linkages.
- Distance learning offers educators staff development and school management capabilities not available through other means.
- Distance learning supports lifelong learning, from adult literacy to higher education. This capability is crucial for workers seeking to update skills and for job training and retraining.

But providing these advantages means that distance learning must meet certain functional requirements to realize its advantages: (1) distance-learning materials must maintain high-quality content and should be continually evaluated; (2) distance learning should itself be supported by training, technical assistance, and professional development, both in school and workplace settings; (3) distance learning should be available in a variety of learning environments; and (4) distance-learning applications should be planned for a multiplicity of uses, including integration with the developing NII.

NAVIGATING THE WORLD OF DISTANCE LEARNING

The USE IT report includes information on distance-learning resources, the integration of technologies, types of service providers, and the use of resources.

Distance-Learning Resources

Distance-learning resources come in a bewildering variety of forms and formats. For the technologically insecure, even the sheer terminology can be overwhelming. The report discusses the following telecommunications technologies, their advantages, and their disadvantages:

Broadcasting. Broadcasting is the earth-based, one-way transmission of video and audio signals, usually within a 35-50-mile range. The nation's extensive broadcasting network(s) are regulated by the Federal Communications Commission. Virtually all distance-learning broadcasting is done from some public broadcasting source, for example, the Public Broadcasting Service (PBS) or some institution of higher learning or public channels. Some 98 percent of all American homes have TV sets that can receive public broadcast signals, and about 94 percent of the country is currently within transmission range of public broadcasting stations. Broadcasting costs are high; costs for seven popular children's series on PBS range from $152,000 to $811,000 per broadcast hour. But on a cost-per-viewer basis, broadcasting's ability to reach huge audiences cuts costs to about a 1-cent per household per program hour.

Satellites. Satellites are basically relay devices for signals; their geosynchronous position above the earth makes it possible to send signals across much greater distances. Reception requires an "uplink" transponder and a "downlink" antenna dish. Approximately 29 commercial satellites are now in orbit, capable of delivering signals to the continental United States and, in some cases, Hawaii and Alaska. Satellite advantages include the ability to transmit anywhere in the United States, resiliency with respect to natural and man-made disasters, and a low cost-to-distance ratio. But satellites are expensive. Apart from launching costs, "uplink" transmission facilities can cost from $80,000 to $300,000 to build, and "downlink" dishes range from $4,000 to $6,000 for standard models. Transponder time costs about $. 30 per hour for a one-year lease. Currently, only about 70-80 percent of the available satellite transponder capacity is in use. Direct broadcast satellites and Very Small Aperture Terminals (VSAT) technologies show promise for further satellite-based distance-learning applications.

Cable. Cable TV sends a signal over coaxial or fiber-optic cable to specially equipped receivers for

a monthly fee. There are 11,160 individual cable systems operating in the United States, which accounts for one of cable's biggest advantages: penetration. Currently, however, only 10 percent of all cable systems in the United States are equipped to provide the interactive services that number among distance learning's most attractive potentials. About 3 of 5 public and private elementary schools (34.5 million students) were cable equipped in 1993, but 95 percent of all high schools will be cable equipped by 1995; 14 percent of community colleges and 22 percent of four-year institutions use cable TV to deliver distance learning. The trend in the cable industry is to replace copper coaxial cable with fiber-optic cable. Fiber-optic's main advantages are its virtually unlimited bandwidth (it can carry enormous amounts of programming and data), its consequent potential for expanded uses, and its reduced need for signal boosting over long distances. Its main disadvantages are its lack of installed base, high costs, and physical constraints in handling and installing.

Telephone. Combined with modems and computers, telephones provide a powerful learning medium. Despite the fact that 95 percent of all American homes have telephones, this technology is not widely used in education; only about 12 percent of U.S. classrooms are telephone equipped. A significant inhibitory factor affecting telephone usage for education is the current rate structures of state public utility commissions. But possibilities exist for creating an "education rate" to complement existing commercial and residential rates. Through fiber optics and other technologies, it is estimated that by the year 2035, 93 percent of all U.S. schools, offices, and households will be served by broadband phone networks.

Microwave/ITFS. Two types of microwave technologies are now being used: (1) point-to-point, line-of-sight transmission of digital or audio signals on the radio spectrum; and (2) Instructional Television Fixed Services (ITFS). ITFS has a more limited range than broadcast TV and costs between $20,000 and $30,000 per channel, compared to the low-end $80,000 to $100,000 cost of a satellite uplink. Four-channel receiving antennas are relatively cheap, at about $150 each. When the unused, commercial-use portions of the ITFS spectrum were allocated in the 1980s, they were bought up by a flood of commercial entrepreneurs. These companies have developed partnerships with educational institutions in which ITFS hardware is provided free to schools. In return, the companies can lease some portion of the four channels allotted per license.

Wireless. Wireless communications technologies include direct-broadcast satellite, broadband broadcast radio, personal communications services (e.g., hand-held radios and cellular phones), wireless local area networks (LANs), and advanced television. Cellular technology is now being used on a very limited basis to transmit and pick up video signals. It is expected that wireless technologies will greatly facilitate delivering the NII to schools and other learning sites and to rural and inner-city areas lacking wired communications.

Computer Networking. Multiple technologies are often combined with a computer network that delivers data and video signals for distance learning. There are currently about 4.5 million computers in America's schools. Since 1989, the number of schools using both internal and external networks has grown substantially, with the fastest growth reported at the upper secondary level. Because computers can store data for later retrieval, networks make interaction among learners, teachers, and service providers much easier. Networks vary greatly in size, scope, and means of communication. Some 38 states now have either fully or partially operational networks for instructional services. LANs connect any number of individual computers, printers, file servers, CD-ROMs, modems, and fax machines. The Internet is a "network of networks," an electronic pathway for data to travel anywhere in the world. There is no "central control"; that means extensive freedom and creativity in using the Internet, with all the advantages and disadvantages entailed. Teachers complain that using the Internet requires a formidable sophistication with computers.

8

Nevertheless, about half the institutions of higher education that are network equipped report participating in the Internet.

Integration of Technologies

These several technologies are seldom used alone; instead, multiple technologies are integrated into systems or networks, a trend facilitated by the widespread use of digital information, which can be more easily transmitted than standard analog signals. Currently, the integration of distance-learning technologies is occurring at two main levels: (1) delivery systems, which transport voice, radio, and data signals; and (2) interface units, which allow users to access and transmit signals on their own. Even when the available technology permits only one of these, the trend is still in the direction of integrating as many technologies as are necessary to provide interaction and support to learners. In 1991, for example, community colleges engaged in distance learning reported using an average of 3.7 different technologies for delivering and receiving instruction, with an expected increased to 5.6 technologies by 1994. Four-year institutions expected to move from 3.4 to 6.1 technologies in the same time period.

Providers of Distance-Learning Resources

Distance learning is packaged in two basic ways: as video programming (live and prerecorded instruction) and as information services (data bases). Providers of these packages range from multistate, nonprofit consortia to independent producers of for-profit information services. This report describes the distance-learning services and technologies of many major providers, for example:

- PBS and its 300+ public television stations.
- The National Technological University, a consortium of 45 leading engineering schools, which offers degree and nondegree programs, as well as credit and noncredit courses;
- The Massachusetts Corporation for Educational Telecommunications, which serves learners in 37 states with satellite programming, electronic networks, and conferencing capabilities.
- The Satellite Educational Resources Consortium, which serves 5,000 predominantly rural high school students from 500 schools in 34 states, 71 percent of whom are eligible for Chapter 1 funds.
- The Black College Satellite Network, which provides programming for prekindergarten through higher education in 23 states, with more than 1,000 participating downlink sites.
- Mind Extension University, which provides fully accredited college and graduate-level courses via cable TV to approximately 25 million households;
- The Agricultural Satellite Corporation, a consortium of land-grant institutions, government agencies, business, and industry, which provides distance-learning services for agricultural producers and rural families and businesses.
- KIDLINK, a free, global program that involves children ages 10-15 in an international dialogue. The interactive service focuses on conversations between participants.

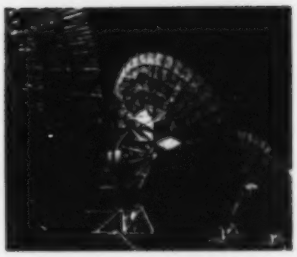
The Use of Distance-Learning Resources

Although comprehensive data concerning the use of distance-learning resources is not available, this report reveals that they are being used at all levels of education, in and out of school. For example, the cable industry reports serving approximately 34.5 million students nationwide. About 4 in 10 of the schools that use distance-learning video programming report receiving it by satellite dish; over a third receive programming by cable television; 9 percent receive programming via ITFS, 5.2 percent via fiber optics; and 4.4 percent via copper-based telephone wiring. Four out of five two-year colleges and 78 percent of all four-year colleges anticipate using distance learning by the end of 1994. Nearly a third of all Fortune 500 companies report using distance learning to train their workers. The report provides a resource-by-resource break-out of how various technologies are typically used. For example:

- Broadcast services are typically used to reach learners both in school and at home; they are seeking to achieve a high degree of interactivity.

HOW TECHNOLOGIES ARE BEING INTEGRATED TO PROVIDE DISTANCE LEARNING

- Fiber optic cable is being used nationwide by all local and long-distance phone companies and many cable companies. A fiber/cable model in Indiana links the Indianapolis Regional Economic/Academic network, Thompson Consumer Electronics, and the Indianapolis schools.
- In Detroit, the Community Telecommunications Network serves approximately half a million schoolchildren by using ITFS as a redistribution system for satellite, cable, and other signals for broadcast microwave reception.
- The San Marcos Telephone Company in Texas has deployed fiber optic cable to connect three education sites: San Marcos High School, the Gary Jobs Corps Training Center, and Southwest Texas State University.
- Maine is currently operating a statewide community college system completely using distance-learning resources, including ITFS, fiber, and an electronic network.



- Satellite use is typically found in school, home, and the workplace.
- Microwave technology is more typically used as a transport link, for example, to link classroom sites participating in live distance-learning sessions.
- ITFS is typically used when a large number of users need to be served in multiple learning sites in a small, defined region of about 30 miles.
- Cable is used in many contexts, from "Cable in the Classroom" documentaries to distributing locally produced courses.
- Telephones are typically used to provide a voice return to a televised instructor, or to connect to online computer services.
- Computer networking is most often used as a secondary form of interaction to support some other distance-learning resource, for example, accessing support materials for a televised class. An emerging use of computer networking is delivering integrated voice, video, and data services directly to a student's electronic desktop.
- Wireless technology is most often used to make the "last link" to the user in unintegrated systems. This is a relatively untested distance-learning option.

CHALLENGES AND BARRIERS TO DISTANCE LEARNING

Despite its growing popularity, distance learning is still a relatively untapped resource with enormous potential to provide improved learning opportunities across the education spectrum. Although many barriers have been overcome, many remain. This report examines the most important of these barriers and offers recommendations, which, taken together, can be instrumental in overcoming them. These recommendations are listed in full at the end of this summary. (The numbered recommendations pertinent to each barrier are provided in parentheses.) Recommendation 1, related to the using distance learning to achieve the National Education Goals, applies across the board.

1 Incompatibility of Technical Systems. Because distance learning incorporates an integration of technologies, compatibility issues are crucial. A typical example is the problems created by the introduction of digital compression technology. Digital compression allows for a much more efficient use of bandwidth and air time, but adopting the technology usually involves new equipment, additional training, and complications in transmissions. Sometimes services have to be offered in both new and old formats to accommodate all users. This particular issue will become more critical as time passes. (Recommendations 3, 10)

2 Insufficient Use of Available Resources. There are many reasons why distance-learning resources are not well used. Not all delivery systems are available everywhere. The haphazard evolution of technologies has created many incompatibilities, inhibiting the integration of distance-learning resources. In many cases, local school systems find it difficult to incorporate distance learning into their existing instructional programs, either because of internal scheduling difficulties or because of scheduling conflicts with cable companies and broadcasters. The rigidity of the school day and year also present conflicts that are difficult to resolve. (Recommendations 3, 4, 6, 9)

3 Costs of Technology. Distance learning involves both significant start-up costs and continuing programming and operational costs. Even audio teleconferencing, a highly accessible and simple technology to use—and low-cost in comparison to using satellite networks—can cost $50 to $400 for each speakerphone and $1,000-$3,000 per port for bridge equipment, plus toll charges. Audiographics equipment can run from $6,000 to $13,000 per school. (Recommendations 6, 9, 10)

4 Regulatory Barriers. All telecommunication systems used to deliver distance learning are regulated by state or federal agencies. Telephone companies and cable companies have made commitments to providing broadband communication networks to schools, but

10

many issues are yet to be resolved, including to whom access will be required, what fee structures should apply to education and training, and what types of services will be provided. These issues are continuously being discussed, negotiated, and legislated. Copyright and viewing restrictions are also significant concerns for distance learning, and intellectual property rights and "fair use" definitions have not yet been clearly defined for emerging distance-learning technologies. (Recommendation 5)

5 Training People to Use Distance-Learning Technologies. This challenge is particularly acute in the schools, where teachers have been inadequately prepared to use distance-learning technologies. One study conducted by the U.S. Congress's Office of Technology Assessment, for example, reported that 64 percent of the teachers involved in teleteaching had not received any prior training in the distance-learning systems used. The American Association of Colleges of Teacher Education reports that only about 20 percent of teacher training programs offer coursework incorporating current learning technologies. (Recommendations 7, 11)

6 Course Accreditation. In general, course-accreditation issues are most significant at the high school level, where state-regulated graduation requirements must be fulfilled by approved curricula and teaching done by state-certified teachers. (Recommendation 2, 8)

7 Cost and Accounting Systems. Whereas most colleges and universities use cost-accounting systems that relate to specific academic departments, most public schools use the accrual method, which does not distinguish between areas of instruction. In consequence, it is difficult for school-based decision makers to estimate or track the cost-effectiveness of using distance-learning technologies, including space and personnel costs. The business community tends to have a clearer picture of the cost-effectiveness of distance-learning technology with respect to its training mission. (Recommendations 5, 9)

8 Institutional Structures. The overwhelmingly local character of education in the United States greatly complicates the use of distance learning. A critical example is teacher certification. Often, a distance-learning teacher must be certified in every state where the teacher's lessons are used. In addition, the organizational structure of both educational institutions and businesses often prohibits effective planning for nontraditional methods of instruction. But state governments have been taking increasing initiative in planning for distance learning to avoid incompatible and duplicate efforts. State planning for using technology in education increasingly includes partnerships between public and private sectors. (Recommendations 2, 4, 8, 10)

9 Programming Quality. An effective on-screen presence requires different skills than does traditional classroom teaching or training in adult education or the workplace. Traditional distance-learning programming formats also tended toward the "talking head" approach. Formats that are much higher in their production values and appropriate to desired content are needed. (Recommendations 7, 8, 11)

10 Awareness and Acceptance. Distance learning is still plagued by the myth that it offers a second-rate alternative to real instruction in a classroom. Schools have been reluctant to turn to distance learning, except to solve teacher shortages, to meet the challenges of great distance in rural areas, or to provide more cost-effective instruction in certain subject areas. In K-12 schools, particularly, distance-learning resources suffer from the "not invented here" syndrome that prohibits ready acceptance of curriculum developed elsewhere and teachers who are not known. Also, distance learning is often saddled with the image of TV as a time waster and negative influence on students. For this reason, it has been used most often for more self-motivated adult learners. A potential remedy for distance learning's awareness and acceptance problems may lie in its wide array of interactive options and feedback systems, and in

its ability to tailor instruction through different modes of learning. (Recommendations 11, 12)

RECOMMENDATIONS

Significant barriers stand in the way of using distance learning to achieve the National Education Goals. The following 12 recommendations have been developed to address them, within the nation's plans for the NII. These recommendations are nationwide in scope and, therefore, general rather than specific to particular states, localities, institutions, or businesses. They encompass an essential principle for the development of distance learning—namely, that such development requires combined private and public action through federal, state, and local education agencies, private industry, and distance-learning service providers. Recommendations are as follows (the rationale for each is provided in the full report):

Recommendation 1: Education agencies at all levels must support the development and use of distance-learning resources to achieve the National Education Goals.

Recommendation 2: Education agencies at all levels must ensure equitable access to distance-learning resources to increase the opportunity for all citizens to learn.

Recommendation 3: The telecommunications industry, distance-learning service providers, and regulatory agencies must support and develop distance-learning delivery systems and information networks that are compatible, interoperable, and cost effective.

Recommendation 4: Federal and state governments, together with local communities, educational institutions, the telecommunications industry, and business and industry, should promote public/private partnerships for distance learning and support regional and statewide applications of distance learning as part of an integrated national resource.

Recommendation 5: State and federal regulatory agencies must develop policies that ensure affordable rates for the educational uses of telecommunications resources. Regulatory agencies having appropriate responsibility should ensure availability of universal telecommunications services for all levels of lifelong learning and maintain reasonable fair-use copyright guidelines for instructional materials used in distance learning.

Recommendation 6: Federal and state agencies, in cooperation with the private sector, should develop new resources for investment and capital development for distance learning. Support from federal agencies must be coordinated to provide efficient and effective funding uses.

Recommendation 7: Professional development programs for educators and administrators should rely increasingly on distance learning and include technical training for the use of distance learning in formal education programs.

Recommendation 8: State education agencies must improve course accreditation procedures to advance the use of distance learning and other alternative education offerings.

Recommendation 9: Providers of distance learning must develop cost-accounting standards that provide accurate information on unit-of-instruction costs and instructional effectiveness assessments for distance learning.

Recommendation 10: Education institution authorities planning to use or expand distance learning must take special actions to create organizational environments for undertaking the values and limits of the service for the desired effects to be realized.

Recommendation 11: Distance-learning providers and users must join forces to strengthen distance-learning content requirements and instructional formats.

Recommendation 12: Local, state, and national authorities should undertake awareness and outreach activities to inform educators, business and industry, and the public of the value and importance of distance learning to achieve the National Education Goals.

This report is the result of the **United States Education and Instruction through Telecommunications (USE IT)** project, a cooperative agreement between the Council of Chief State School Officers (CCSSO) and the National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce, with participation by the Office of Education Research and Improvement (OERI) of the U.S. Department of Education. In January 1993, these groups collaborated to assess current and future educational needs in the United States relating to distance learning and to develop recommendations for using telecommunications and learning technology resources for distance learning to achieve the National Education Goals.

The project was funded by NTIA's Public Telecommunications Facilities Program (PTFP). PTFP assists noncommercial entities to purchase telecommunications equipment that will be used to produce and transmit educational and cultural services. PTFP also supports planning projects pointed toward these ends. Over the years, PTFP has offered financial support to diverse organizations—public broadcast stations and all levels of academic institutions—to help them establish, extend, and plan for distance-learning systems.

We should note that, since this grant was funded, NTIA has been given an important role in the Administration's wide-ranging National Information Infrastructure (NII) initiative. This initiative will be discussed in greater length elsewhere in this report. As part of its NII-related responsibilities, NTIA has established the Telecommunications and Information Infrastructure Assistance Program (TIIAP). The TIIAP, which distributed its first grants in October 1994, awards monies to such entities as state and local governments, museums, libraries, health care providers, school districts, colleges and universities, public safety services, and nonprofit organizations to help them interconnect with the new telecommunications and information networks.

CCSSO is a nationwide, nonprofit organization composed of the 57 public officials who head the departments of elementary and secondary education and, in some states, other aspects of education in the 50 states, five extra-state jurisdictions, the District of Columbia, and the Department of Defense Dependents Schools (DoDDS).

PREMISES OF USE IT

The USE IT project embraces several basic premises concerning education, technology, and distance learning. These premises emerged from extensive evaluation and analysis of current literature regarding technology and education; consultations with a wide range of government, business, and education representatives; and the clearly defined vision of the Clinton Administration for the capabilities of applying the nation's technological resources and prowess to improving education in this country. The premises are as follows:

1. The objectives for learners, as included in the National Education Goals, determine how technology is applied to learning and teaching.
2. Distance learning offers great promise in providing educational services, chiefly because information and telecommunications technology provide access to instruction and content that students at all levels could not otherwise have.
3. Distance-learning technologies increase learning effectiveness by offering diverse interactions ranging from "one to many" to "many to many" for learning.
4. Distance learning is a source of cost-effective professional development for teachers and school administrators.
5. Distance learning enables schools to use the most effective teachers available in a given subject area, without geographic limitations.
6. Changes in information technology are having a powerful effect on how those technologies are being designed and used in education.
7. Developments in telecommunications and distance-learning policy and operations for education are closely related to developments in general telecommunications policy.
8. Initiatives, support, and direction for telecommunications policy, operations, and financing will come from both public and private sectors.

13

METHODOLOGY FOR THE PROJECT AND REPORT

The USE IT Project is a collaborative effort by education, business, and government organizations to assess current distance-learning resources and develop strategies and recommendations for using these resources to achieve the National Education Goals. A Governing Board, Steering Committee, and Forum provided input and guidance to the content and structure of the report. The project management team, consisting of representatives from NTIA and CCSSO, commissioned consultants to draft position papers for specific sections of the report. The team held a national teleconference on August 6, 1993, featuring discussion by a distinguished panel of the issues central to the application of telecommunications to education and providing an opportunity for interested people across the nation to participate in the dialogue. Portions of this report reflect this dialogue.

The report examines all levels of education, from prekindergarten through adult continuing education and worker training. This breadth reflects the recognition by the education community of the necessity for lifelong learning and the recent efforts to achieve systemic reform that links all aspects of education. A review of studies and reports by the project management team found that the K-12 uses of distance-learning programs were more heavily documented than were comparable studies for adult learning, higher education, and worker training. Reflecting this limitation, data presented here provide more information about K-12 education than the other levels; but the team's intention is not to emphasize the importance of distance learning to one level of education over another. The report includes discussions of multiple telecommunications and learning technology resources. It reviews policy issues and strategies to better provide education services using telecommunications and learning technologies for distance learning. The report does not advocate one type of technology over another; rather, it indicates the capacities and potentials of different types of technologies. It assumes that learners will use a variety of technologies that best suit their immediate needs.

The Governing Board met in April 1993 to discuss the scope of the project and a means for producing materials for review. Recognizing the broad scope of the project, limited time schedule, and diverse interests of the project participants, the Board formed three working groups to produce three working papers on: functional requirements for achieving the National Education Goals; telecommunications resources; and strategies to maximize use of telecommunications resources to achieve the National Education Goals. The Board designated these three papers as the framework for the final report of the project. The paper on functional requirements would develop a statement of vision about the nature of learning in our society and the expectations for learning in a changed technological context. The paper on telecommunications resources would not take a quantitative approach to inventorying resources; instead, exemplars of systems that successfully integrate telecommunications and education would be identified and presented. Strategies would be developed to maximize use of telecommunications resources to achieve the National Education Goals and would be directly linked with the functional requirements and identification of resources.

The project management expanded on the discussion at the Governing Board meeting and presented preliminary drafts of the three papers at the Steering Committee meeting in June 1993. The Steering Committee divided into three working groups to comment on and further develop the working papers. The project management and an advisory team from the Governing Board selected the Southwest Regional Laboratory (SWRL) to conduct a literature search on the impact of telecommunications on education from 1980 to 1993.

The Governing Board convened a second time in August 1993 and continued to review and revise the working papers and support materials. Three consultants, Susan Fratkin, Richard Hezel, and Saul Rockman, who are leaders in the field of

14

education and technology, attended the meeting and met with the working groups. Following the meeting, the consultants prepared revised versions of the working papers, which were distributed to Governing Board and Steering Committee members for comment. Four additional consultants, Pam Pease, Ron Anderson, Judy Gray, and John Cradler, were retained to develop papers describing the use of cable television, computers, telephones, and networks in distance learning. These papers were incorporated into Chapter 2, "Distance-Learning Resources."

The Steering Committee met again in December 1993 to review a preliminary draft of the final report, based on the conceptual framework established by the working papers. Following the meeting, the NTIA and CCSSO project management team, under the cooperative agreement, prepared an outline for a new draft of the report, which would incorporate work completed to date, expand on the identification and analysis of distance-learning resources, and refine the content to more specifically guide the role of NTIA in distance learning. NTIA and CCSSO worked closely over the next several months to update the research conducted for the project and draft the report based on the new outline.

After the project management team completed the revisions, copies of the draft were sent to members of the project Forum, representing more than 70 government, business, and education organizations. The team incorporated comments by Forum members into the final report, which was submitted to the Governing Board for approval in December 1994.

Time and resource constraints of this project limited original surveying and data collection by the project management team. The team relied heavily on data already assembled by states, institutions, companies, and associations. The team contacted state education agencies, public service or utility commissions, and land grant colleges by letter requesting information about available telecommunications resources and integration of telecommunications into education. Responses varied in both quality and quantity. To this extent, much of the information collected from these sources has been summarized or used as background material for providing the context of the report. The project management team also conducted phone and personal interviews with service providers, educators, government officials, technicians, engineers, and other leading figures involved in technology and education. The team conducted research on many publications, including reports by government agencies, industry, and public advocacy groups; articles in journals, newspapers, magazines, and trade publications; monographs identified through the ERIC database; speeches; and other relevant print materials. Team members reviewed several dozen videotapes. The team attended several meetings and conferences conducted by government agencies and nonprofit organizations to assess the latest trends in distance learning and education policy.

Because information was collected from so many sources, the level of detail concerning descriptions of technologies, service providers, and users varies accordingly. Extraordinary technical developments and change in pricing and availability; rapid changes in implementation of technologies; unevenness of progress among states, local districts, and institutions; and variations in cost related to isolated applications of technology make aggregate, quantitative findings extremely difficult. They are presented in the report to the greatest extent possible. During extensive contact with experts in the field at all levels and in varied professional positions, the project management team discovered that data collection and assessment in the field of distance learning is limited. The team has used the most reliable and accurate sources of information available, but it should be noted that this is a dynamic and emerging field in education research and application.

This report is considered to be applicable to the continental United States, Alaska, and Hawaii. Although some aspects of distance learning, as discussed here, may also be applicable to the U.S. territories including Puerto Rico, American Samoa, and Guam other aspects may be invalid within the unique circumstances and opportunities in these areas.

This report explores the use of distance learning to promote improvements in education aimed at meeting the demands of a modern society. Two distinct trends set the stage for this discussion. The first is our rapidly changing information society, in which telecommunications and information technologies have stimulated a globally competitive economy and a constantly changing workplace. The second is an unprecedented national commitment to education reform, the culmination of decade-long efforts to define improved learning and take this country from being "a nation at risk" to a model of world-class education. Understanding the potential of telecommunications technology is not only essential to functioning in the modern workplace, but is a powerful tool for improving educational opportunities for all citizens. Recognizing this potential, the U.S. Congress enacted the technology component of Goals 2000: Educate America Act in March 1994. The Goals lay out comprehensive national objectives for education in this country, including school readiness, excellence in science and mathematics, adult literacy, professional development, a well-prepared work force, and safe learning environments.

In past decades, distance learning has filled gaps in existing education and stretched instructional resources across geographic boundaries. Now, however, the opportunity exists for distance learning to play a significant role in achieving the nation's education goals. Telecommunications resources—including broadcasting, satellite, cable, telephone, and computer networks—which are already working to deliver distance learning, will soon be integrated into a National Information Infrastructure (NII). Education and learning must be a primary function of the NII if it is to serve Americans, and distance-learning applications already in place must continue to evolve into access ramps for the NII. In this context, distance learning has limitless potential for ensuring opportunities for lifelong learning for all citizens.

16

THE CHALLENGE OF EDUCATION REFORM

The economy and labor markets in the United States are undergoing dramatic restructuring as a result of advances in technology. Both the nature of work and the bases of productivity are being redefined. The least skilled jobs in the American economy are disappearing. Most new jobs will require more education—particularly higher levels of language, mathematics, and reasoning skills. The rapid technological changes within jobs and the increased mobility among jobs mean that workers need to adapt to new situations and be able to learn new skills throughout their lives. New workers entering the labor force today can no longer count on remaining in the same jobs or working in the same industries until retirement. As old industries decline, new jobs are created that require Americans to be technologically literate, creative problem solvers.

The traditional workplace of the past was characterized by mass production, centralized control, and fragmentation of tasks. The high-performance workplace of tomorrow, in contrast, will be distinguished by flexible production, decentralized control, and teams composed of multiskilled workers (Secretary of Labor's Commission on Achieving Necessary Skills [SCANS], 1991). These changes place enormous demands on both our workers and on the education and training institutions that the nation relies on to prepare young people for productive lives. The challenge for education, therefore, is not to train workers for new technical occupations and careers, but to produce well-educated citizens, prepared for continual change and for the lifelong, independent learning required to accommodate change effectively (National Commission on Excellence in Education, 1983; Resnick, 1987; Resnick & Resnick, 1992; Scribner, 1987).

Research on learning and cognition suggests that traditional approaches to education and training will not produce the kind of adaptive learning or the kind of learners required by changes in technology, work, and society. New learner-centered approaches are needed now. In these environments, students actively construct knowledge for themselves, cooperate in problem solving, and learn skills in the context of meaningful, real-world tasks (SCANS, 1991). The systemic reforms now being contemplated are based on this vision of effective learning in the information age. The Goals 2000: Educate America Act and other initiatives focused on elementary and secondary schools, school-to-work transition, and adult literacy, offer a framework within which systemic education reform can be pursued. At the center of these initiatives are the National Educational Goals, which provide, for the first time, national benchmarks for the kinds of educational opportunities the education system should provide and the levels of accomplishment that all school-aged learners and adults should achieve (U.S. Congress, 1994) (see Figure 1). The Star Schools Programs have already developed a wide range of successful distance-learning services aimed at supporting the National Education Goals, including instruction modules, electronic field trips, otherwise unavailable coursework, access to experts in a variety of fields, and career awareness programs (Far West Educational Laboratory, 1994). The cable industry has also initiated projects aimed specifically at helping communities achieve the National Education Goals (Decker Anstrom, personal communication, January 1995).

The Goals 2000: Educate America Act makes clear the importance of technology in its Leadership in Education Technology initiative. The legislation calls on federal leadership to develop a national vision and strategy for educational technology, including technology planning that is integrated into all state education and training programs, is coordinated among public and private entities, ensures maximum interoperability, and is facilitated by federal policies. Clearly, distance learning has an important role to play in defining this vision and ensuring its objectives.

New approaches to learning are necessary to prepare all Americans for the 21st century workplace.

NATIONAL INFORMATION INFRASTRUCTURE

The tools of telecommunication, including broadcast, satellite, cable, and telephone networks,

17

Figure 1
THE NATIONAL EDUCATION GOALS

GOAL 1: By the year 2000, all children in America will start school ready to learn.

GOAL 2: By the year 2000, the high school graduation rate will increase to at least 90 percent.

GOAL 3: By the year 2000, all students will leave grades 4, 8, and 12 having demonstrated competency over challenging subject matter including English, mathematics, science, foreign languages, civics and government, economics, arts, history, and geography, and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our Nation's modern economy.

GOAL 4: By the year 2000, the Nation's teaching force will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to instruct and prepare all American students for the next century.

are already being used for education and instruction. The NII promises to bundle these powerful tools and deliver them in ways that provide users with improved access to full voice, data, and video services. Recognizing the potential represented by this convergence of technologies, the Clinton Administration has sought explicit linkages between the NII and the National Education Goals, challenging business leaders, the education community, and others to link every classroom to the NII by the year 2000 and to provide access to learning resources through libraries, museums, and other community institutions (State of the Union Address delivered by President Clinton, January 1994; remarks of Vice President Gore to leading executives in the computer and multimedia industries, Los Angeles, February 1994). Increasingly, Americans rank education and instruction as the most important benefit to be received from the NII (Benton Foundation, 1994).

For distance learning, the convergence of technologies represented by the NII offers several important advantages: (1) the potential for individual learners to tap into a broad range of distance-learning programming from any location using any number of interface devices, rather than having to use particular technologies at a particular receiving site; (2) more varied means of interactivity, which will make it more feasible to customize the distance-learning applications to the subject matter taught, the characteristics of learners, and the mix of local resources available; and (3) the possibility of integrating distance-learning programming with other technology-supported learning. Each of these capabilities enhances the utility and attractiveness of distance-learning services for achieving the nation's education goals.

ROLE OF DISTANCE LEARNING IN EDUCATIONAL REFORM

Telecommunication and information technologies offer a range of resources that can serve as engines for many of the powerful education and training reforms needed to advance Goals 2000 (see Chapter 2 for a more detailed discussion of these resources). This has been the conclusion of several groups of educators, businesspeople, the policy leaders interested in using technology to improve teaching and learning and to restructure schools. Already, telephones provide connections to distant experts, to remote data bases, and to helpful teachers who answer homework hotlines in many cities. Broadcasting provides education and training courses for distance-learning applications through the Public Broadcasting Service (PBS), public television stations, and public radio. Television provides a variety of educational programs: programs for young learners such as Sesame Street, Reading Rainbow, Square One, and CNN Newsroom; adult education courses and community college offerings; and documentaries and debates on topical issues. Cable networks such as Arts and Entertainment, The Discovery Channel, The Learning Channel, C-Span, and many others all provide educational programs for formal or informal use. Microwave, Instructional Television Fixed System (ITFS), and local area computer networks provide professional development opportunities for teachers and facilitate communication among learners, teachers, and administrators.

Distance learning encompasses a broad range of technologies (see Chapter 2). These resources serve a variety of functions: full-length courses for credit; modules of instructional units that can be integrated into traditional classroom instruction; enrichment experiences that bridge the distance between classrooms and the world beyond; and professional development programs that support teachers and working professionals. Distance-learning programs either offer services to students who would not otherwise have access to them, or enrich the quality of learning services already available.

Traditional distance learning delivered instruction to remote sites or to places where teachers in a particular subject matter were unavailable, and this remains one of its most important functions. Distance learning is helping many institutions to extend otherwise unavailable educational opportunities. The Star Schools program, which delivers distance-learning services nationwide, continues to

18

find foreign languages, mathematics, and science courses among the most popular programming. A recent survey of small, rural school districts in 32 states found that half of them used distance learning. Satellite and cable are the most commonly used delivery systems in these districts. Again, foreign languages, mathematics, science, and vocational education were noted as the greatest programming needs (Barker & Hall, 1993). In K-12 education, distance learning is most often used for this purpose.

Learning technologies, particularly those telecommunication resources used for distance learning, also have great potential to provide enriched educational experiences. As use of learning technologies becomes more widespread, and resource-rich learning environments become the norm, distance-learning systems will be increasingly helpful for improving current instructional practices. Turner Educational Services' electronic field trips illustrate one of the ways in which distance learning can provide enriching new educational experiences that enhance the existing curriculum. Although the "vicarious" field trip to Gettysburg—complete with a live question-and-answer session with historians—is not part of a structured course, its potential benefit to a text and lecture-based high school history course is evident.

Distance learning can also strengthen mathematics and science instruction throughout the curriculum (Campbell, 1994; Tushnet, Bodinger-deUriarte, Manuel, von Broehuizen, & Millsap, 1993). New curriculum standards call for all students to learn more challenging mathematics and science and to be introduced to advanced concepts in earlier grades. Increasingly, distance-learning programs now provide much-needed support in these areas to classroom teachers, many of whom do not have strong foundations in either of these disciplines. For example, Telecommunications Education for Advances in Mathematics and Science (TEAMS), a collaborative program operating in school districts nationwide, offers participating schools comprehensive packages for science instruction that include telecourses, lesson plans and other support materials for teachers, and materials to provide hands-on activities for students (Tushnet et al., 1993).

The focus of education reform is improved elementary through adult education, better school-to-work transition, and increased opportunities for worker training. Participatory learning and multidisciplinary, collaborative work that is based on real-world tasks are important components of quality education (U.S. Department of Education, 1993). Leaders of business and industry have also called for a more intelligent work force, better able to analyze situations and solve complex problems (SCANS; 1991). Distance-learning programs are, in fact, uniquely able to achieve some aspects of improved learning, including opportunities to connect school learning to applications in the workplace by electronically linking those communities. Two-way satellite and fiber networks, teleconferencing, and other similar systems can combine collaborative learning and audiographics, for example, in ways not previously possible. Usually video-based, instructional programming can use three-dimensional graphics and other dynamic images in ways that traditional lecture and text-based instruction cannot. Telecommunications is in a unique position to provide educators with staff development resources and management capabilities. Goals for improved education invariably recommend that teachers take a more active role in developing rich learning experiences (e.g., National Council of Teachers of Mathematics [NCTM], 1991). New roles will include responsibility for creating and customizing instruction, conducting authentic student learning assessments, and communicating regularly with parents (U.S. Department of Education, 1993). To effectively take on these roles, educators will need to take part in information-sharing and collaborative processes that professionals in other fields take for granted. Information about the latest research application, technique suggestions, and valuable resource-sharing among colleagues are often inaccessible for most teachers. Coordinated distance-learning systems, particularly those incorporating specialized broadcast programming and electronic networks,

GOAL 5: By the year 2000, United States students will be first in the world in mathematics and science achievement.

GOAL 6: By the year 2000, every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.

GOAL 7: By the year 2000, every school in the United States will be free of drugs, violence and the unauthorized presence of firearms and alcohol and will offer a disciplined environment conducive to learning.

GOAL 8: By the year 2000, every school will promote partnerships that will increase parental involvement and participation in promoting the social, emotional, and academic growth of children.

provide a powerful opportunity to fulfill these needs (Center for Educational Leadership in Technology [CELT], 1994; Computer Science and Telecommunications Board of the National Research Council, 1994; U.S. Department of Education, 1993).

Distance-learning technologies also support lifelong learning, from adult literacy to higher education and worker training opportunities. Although limited use is made of technology in most adult education programs (U.S. Congress, Office of Technology Assessment [OTA], 1993), that situation is beginning to change as technology becomes more commonplace in public schools and community settings.

As the labor market increasingly requires workers to update their skills, job training and retraining become consistently important factors in achieving high levels of productivity and competitiveness. Distance learning offers opportunities at these levels, as well. Telecommunications and information technologies also are seen as the key to making workplace training accessible and affordable, particularly for small to medium-sized firms (National Institute of Standards and Technology [NIST], 1994). National Technological University (NTU) makes telecourses available to engineers, scientists, and technical managers, most of whom are working professionals sponsored by their companies. NTU, Mind Extension University, PBS Adult Learning Services, and other national distributors present new possibilities for collaborative learning by bringing adult education to a national classroom.

FUNCTIONAL REQUIREMENTS FOR USING DISTANCE LEARNING

For distance learning to realize its potential and promote achievement of the National Education Goals, the best of technology must be integrated with the best of instructional practice for delivery to the widest possible audiences. Viewed in more operational terms, if distance learning is to be appealing and judged effective on a large scale, certain functional requirements related to educational, technical, and access considerations must be satisfied.

Distance-learning materials should maintain high-quality content and should be continuously evaluated.

Materials used through distance learning, whether they are entire courses, a video segment used to demonstrate a concept in a class, or information for a report retrieved from a database, must be of high quality in design, presentation, and content. The materials must facilitate the desired learning outcomes in a way that is compatible with curricular objective, learning styles of students, and the learning environment. Unless learning materials meet these criteria of high quality and functionality—including appropriate levels of interactivity—they are unlikely to be widely implemented. For uses of distance learning meant to enrich existing education, content is particularly important, because people are less likely to use any learning technology unless it clearly serves the needs of improved instruction and is compatible with content frameworks (U.S. Department of Education, 1993).

Distance learning is an evolving field, and published literature on the topic is overwhelmingly anecdotal. In addition, because most distance-learning programs are tailored to specific school, business, or industry needs, evaluations are most often informal and conducted by users, not independent sources. When large-scale evaluations have been conducted, they have often been based on strict comparisons with equivalent classroom instruction and tended to focus on issues such as usability, learner preferences, and equipment quality, rather than learner outcomes. Because distance learning is changing constantly, including varieties of media and modes of interactivity, traditional research methods are often insufficient (Schlosser & Anderson, 1994). As methods of teaching and learning change, and more learning technologies are available, the importance of evaluation and studies that take into account the unique characteristics of technology-based education will continue to increase (Block, Guth, & Austin, 1993; Kearsley, Hunter, & Furlong, 1992; Tushnet et al., 1993).

Distance-learning use should be supported by training, technical assistance, and professional development.

One of the most important criteria for effective technology-based instruction is a well-prepared and supported teacher (Pearson, 1989; Schlosser & Anderson, 1994). Preparation and support of teachers in the context of distance-learning technologies involve both learning how to use distance-learning resources in the classroom and having the opportunity to use distance learning as a resource for professional development. Teachers continue to be responsible for managing an expanding array of communication and information tools, acting as resource facilitators who guide learning, rather than distribute information (Withrow, 1994). Preservice and inservice training programs should incorporate technology throughout teachers' education, instructing teachers with the same tools they themselves will be expected to use (Portway & Lane, 1992). Although technical assistance is usually necessary, distance-learning systems should also be reliable and easy to use. Ease of use has proven to be one of the most important factors determining the use of telecommunications technology by teachers (Honey & Henriquez, 1993). Many other studies note the importance of usability to program effectiveness (e.g., Minninger, 1993).

Distance-learning resources should be available in a variety of environments.

Distance learning should be accessible in a variety of learning environments, including schools, workplaces, libraries, and community institutions. Ideally, business and industry can work together with education and community organizations to provide students of all ages and situations an opportunity for lifelong learning. Broadcast, satellite, telephone, cable, fiber optic, ITFS, and microwave systems link communities to create dynamic learning environments. These technologies not only allow communities to share local and national programming, but can provide opportunities for voice, video, and data conferencing. It is clear that shared technology resources are not only cost effective, but provide important links between communities. Proponents of distance-learning applications for vocational education have been particularly interested in the possibility of linking education with real-life experiences (Gooler & Roth, 1990). This type of collaboration is a natural benefit of community-based, learning-technology systems and must be encouraged.

Distance-learning applications should be planned for multiplicity of uses, including integration with the developing National Information Infrastructure.

Distance-learning systems, whenever possible, should support administrative functions, communication needs, information management, and other uses. Being able to use distance-learning technologies as part of a larger telecommunications system improves both cost effectiveness and coordination between instructional and administrative functions. Such networks are intended to provide cost-effective improvements in the areas of communication and administration, as well as instruction. In addition, planners of distance-learning systems should keep in mind potential links with other institutions and organizations. The NII intends to link institutions, businesses, individuals, and resources for many applications. Planners include federal and state agencies, private industry, and telecommunications service providers. Users of distance learning for education and instruction must take an active role in coordinating resources and planning for cooperative community and national networks.

Distance learning can both enhance existing education and provide learning opportunities where they did not exist.

The 1990s represent a time of unprecedented change, challenge, and opportunity for the United States. These changes hold dramatic implications for how we educate today's students for work and for citizenship in the 21st century. Necessary improvements in education, as outlined by the National Education Goals, advances in telecommunications technology, and plans for construction of the NII, are all converging. This is an exciting and important time for distance learning and its potential for providing all citizens with the opportunities for learning necessary for success in today's society.

This chapter reviews resources available to educators for distance-learning services. These resources include the major telecommunications technologies used to deliver these services, the integration of these technologies to provide access, the major providers of distance-learning services, and the users of these services.

Using primary and secondary sources, including reports, journal articles, and personal communications with experts in the field, we provide a general overview of each telecommunications technology. The report discusses in detail only those technologies currently used to provide distance learning and only those aspects of the technology relevant to the delivery of services. Technical descriptions are beyond the scope of this report. We describe each technology in the context that it is used to deliver distance-learning services to elementary and secondary school learners, higher education learners, adult education learners, and worker training learners. Although many of the technologies have specialized applications, such as assistive broadcasts for disabled persons, they are not explored in detail here. We acknowledge that there are many emerging technologies still in development with the potential for distance-learning applications. We discuss some of these, such as the fast-growing cellular technologies; but this chapter should not be considered an all-inclusive listing. The "References and Resources" section of this book provides references to the citations to available literature and lists the people and organizations that we have cited as resources.

The focus of the chapter is on showing the diversity of both the available technologies for delivering distance learning and possible applications of those technologies. In general, we describe how the technologies function; and we provide cost estimates and technical evaluations of capacity, speed, and application where available. Research methodologies for each section in this chapter varied, due primarily to the broad scope of some issues, limited available information for specific areas, and internal research constraints.

To better describe the parameters for our discussion in this report of distance-learning technologies, we offer the following definitions:

- Distance learning is the delivery of video, voice, or text instruction or information to a learner over distance, from one location to another, using some form of telecommunications technology. The distance may be local, from one classroom to another in a remote site only a few miles away; regional, from a computer at office headquarters to a worker's desk in another state; or even international, from a teacher in Germany to a classroom in the United States.
- Telecommunications technologies are tools that transmit an electronic voice, video, or data signal over distance either through a wire or using the electromagnetic spectrum. The major telecommunications technologies addressed in this report as being used for delivering distance learning are broadcasting, satellite, cable, telephone, microwave/ITFS, wireless, and computer networking. Fiber optic technology is addressed in the delivery of both telephone and cable services.
- Integration of technologies occurs when multiple telecommunications technologies are used to deliver distance learning from one location to another. Because these integrations occur in unique ways in each school, community, and workplace application, only some examples of technology integration are illustrated.
- Providers are the organizations that develop, produce, or distribute programming, learning materials, and information for distance learning.

22

The report provides a description of some major providers of distance-learning services in K-12, higher education, adult education, and workplace training. Many programs and materials are "custom made" by a particular institution, district, or company. This section, therefore, relies primarily on examples of large-scale service providers and significant regional or local programs.

- Users are the learners at the primary, elementary, secondary, higher education, adult education, and workplace training levels who are using distance-learning services as a resource for learning. Many distance-learning activities, both for formal and informal education, are neither documented nor evaluated in central sources, and minimal reliable data on usage exists. This section provides a summary of how some users are incorporating a variety of services to fulfill their particular education needs.

TELECOMMUNICATIONS TECHNOLOGIES FOR DISTANCE LEARNING

Broadcasting

Broadcasting is the terrestrial-based, one-way transmission of video and audio signals from a transmission tower to any point within range of transmission with a receive unit, either a television or radio. Transmission range is usually about 30-35 miles, depending on height and power of the transmission tower and geographical idiosyncrasies. Although reception does not require line-of-sight with the transmitting tower, it can be hampered in mountainous regions and by interference from other electrical signals. Transmission range can be extended by implementing signal repeaters, translators, and microwave towers. Signals are originated at a main station, which usually contains video, editing, and transmitting equipment.

The nation has an extensive system of commercial and public broadcasting networks regulated by the Federal Communications Commission (FCC), which licenses all stations and infrastructure. Practically all bandwidth in the electromagnetic spectrum designated for commercial and public television and radio broadcasting has already been allocated. Therefore, to obtain a broadcasting license, either a current license must be revoked and reallocated, or a spectrum must be repurposed from some other use and designated for broadcasting. Each license allocates use of one channel for broadcasting. A channel can deliver only one program at a time.

Broadcast television is used regularly for formal and informal distance-learning purposes. Traditionally, it is used to send a live or previously recorded program to a large audience. Educational program content includes documentaries and classroom-style instruction. Since commercial broadcast television does not provide much educational programming on a regular basis, focusing more on the entertainment market, this report will concentrate on public broadcasting. Ninety-four percent of the country currently is within transmission range of public television broadcast stations. Another 4 percent of the nation can receive the broadcast programs through cable or satellite feeds (Somerset-Ward, 1993). Ninety-eight percent of U.S. households, totaling 92 million homes, have televisions capable of receiving the public broadcast signal (Chen, 1994). Although only 25 percent of the nation's K-12 classrooms have televisions (Chen, 1994), most schools have either a television on a media cart, which can be moved from classroom to classroom, or a designated room to which classes can go to use a television.

The significant advantage of using broadcast television to deliver programming is that it is a wireless technology that does not require homes, schools, and other learning sites to invest heavily in new infrastructure. Television is a ubiquitous technology, with retail prices of 20-inch television sets in the $300 range. With almost 100 percent of the country covered by public broadcasting signals, the transmission infrastructure is already in place. Although broadcasting itself is used mostly as a one-way technology, a telephone line can provide audio interaction between the viewer and the

Distance-learning technologies—broadcasting, satellite, cable, telephone, microwave/ITFS, wireless, and computer networking—are being used by schools, regional collaboratives, colleges, and businesses in many applications to meet particular learning needs.

program if it is being viewed live. Using a videocassette recorder (VCR), broadcast programs can be recorded for later viewing.

Access to television broadcast airtime is severely limited due to the scarce spectrum available. Any given community is likely to be served by only one or two public television stations, whose mission extends beyond education to include cultural and news programming. The open signal used by broadcasting prevents monitoring for billing purposes and does not allow for privacy or security of transmitted information.

Producing high-quality video programs and transmitting them are expensive endeavors. For example, production costs for seven popular children's educational series produced for the Public Broadcasting Service (PBS) ranged between $152,000 and $811,000 per hour, averaging $380,000 per hour (Corporation for Public Broadcasting [CPB], 1993). It may be difficult to find the initial capital to finance the high cost of developing this type of programming. However, the ability to reach large audiences makes the user/cost ratio fairly low. The cost of providing a one-hour educational program such as *Sesame Street* to a single household is less than $0.01 per household for each program (Keith Mielke, personal communication, May 20, 1994). Lower production value programming, using lower-grade cameras, sound, and editing equipment, and fewer personnel, costs significantly less than highly produced programming and is used primarily for classroom-style instruction. For example, production costs for a simple studio with two cameras may cost as little as $1,000 per hour, including broadcast air time (Matt Miller, Northern Virginia Public Television, personal communication, June 16, 1994).

In adult education, a number of public television stations provide distance-learning programs, often in the form of telecourses that are offered through one-way video transmission and interaction through telephone lines. The technology resources located at public television stations make them potential "technology centers" for the community, capable of serving as a switch for several telecommunications technologies. For example, the satellite dishes used to receive programming for broadcasting may also be employed for participating in a national teleconference.

Low power television (LPTV) is being used in some areas of the country to broadcast standard television signals over a short distance, a maximum of 20 miles. LPTV allows regions to use more channel capacity without interfering with the transmissions by the higher-powered commercial and public broadcast stations in the area. Because the transmission towers required for LPTV are significantly smaller than for standard broadcasting, the startup costs are far lower.

High-definition television (HDTV) is an emerging broadcast technology that promises almost twice the vertical and horizontal resolution of standard broadcast television and audio of similar quality to compact discs. The broadcast signal requires approximately five times the bandwidth of conventional broadcast television. FCC is in the process of reviewing standards and developing regulatory policy for HDTV. PBS reports that it will be presenting some of its programming in HDTV format, but it is not anticipated at this time that distance-learning programming will be in HDTV format (Carl Girod, Public Broadcasting Service, personal communication, June 10, 1994).

Although distance-learning applications of public broadcast radio are much less extensive than television, some services are available. Most public radio stations, like their television counterparts, tend to provide entertainment and informal educational programming. Some stations, such as Wisconsin Public Radio (WPR), however, have developed more structured learning services. WPR began broadcasting music appreciation, agriculture, and consumer science courses in the 1920s. This service eventually expanded into the "School of the Air" courses that were broadcast via subcarrier to public schools until the 1970s. In the early 1980s, the station began a partnership with the Annenberg/CPB Project to produce a series of audio-print courses, some of which can now be taken for college credit. Ranging in sub-

ject from fundamentals of music for secondary school students to history and psychology, the courses usually consist of taped lectures accompanied by print materials, including study and faculty guides. The courses are primarily distributed to educational institutions and libraries for in-class or distance-learning uses, but are also available to public radio stations for broadcast. WPR plans to expand broadcast applications for their programming, and is working with university public radio licensees to broadcast the audio-print courses to off-campus students who do not have convenient access to libraries or media-centers (Dan Peterson and Sylvia Potempa, WPR, personal communications, June 1994).

Satellites

Satellites serve as relay systems to broadcast video, audio, and data signals over extremely large areas. A satellite, usually in a geosynchronous orbit so that it remains in a constant position above the Earth, receives a signal from an *uplink* transmitter dish, and then transmits the signal back toward the ground. The geographic area covered by the transmission is called the *footprint*. Unlike standard broadcasting, satellite transmissions cannot be directly received using a television, radio, computer, or other user interface device. Reception requires a *downlink* antenna dish aimed at the satellite and within the footprint. The signal, once received by the dish, is then usually transmitted by wire or broadcast to the user, who may have a television, telephone, or computer to interface with the signal.

Approximately 29 domestic commercial satellites in orbit are capable of delivering signals to the continental United State and, in some cases, Hawaii and Alaska. Each satellite carries between 16 and 24 *transponders*, the device that receives and transmits video, audio, and data signals. Although most transponders deliver one or two channels of video programming each, advances in digital compression are increasing the transponder capacity to 6-10 channels. PBS reports that by July 1, 1994, four of its programming signals will be carried on a single transponder using digital compression; and by 1996, all of its signals will be transmitted in a digitally compressed format (Carl Girod, personal communication, June 10, 1994). Most transponders operate on one of two frequencies: *Ku-band* or *C-band*. Ku-band is a high-frequency band that sends a stronger signal to Earth than C-band, therefore requiring smaller and less expensive downlinks. Though C-band better withstands interference from inclement weather than Ku-band, Ku-band does not succumb to interference from terrestrial microwave transmissions as C-band does and can be used with a smaller receive dish. Some downlinks have the capability of receiving both Ku- and C-band signals.

The benefits of satellite communications systems include ubiquity of signal delivery to the entire continental United States, relative cost insensitivity to distance of transmission, and resiliency with respect to natural and man-made disasters. Satellites are currently being used in education at all levels to deliver voice, video, and data signals. For video-based, interactive, distance-learning services, satellite delivery is often used because of the ability of any geographic location in the continental United States to receive the programming if they have a dish. This expands the potential economy of scale of producing and delivering the programming. However, larger audiences also decrease the likelihood that a learner will be able to be interactive with the programming in real time.

Transmission systems using satellites can be relatively expensive to implement and operate, even omitting the cost of building, launching, and operating the satellite itself. Uplink facilities can cost upwards of $300,000 to build, depending on several variables, including model level (commercial vs. professional), mobility (steerable vs. fixed), and options (de-icing mechanisms are required in colder climates). Costs of downlink dishes with receivers (which convert the signal from the dish to the television) range from $4,000 to $6,000 for a standard steerable model about 3 meters in diameter, commonly used by many schools, businesses, and homes (Carl Girod, personal communication, June 10, 1994; Charles Mellone, National

Telecommunications and Information Administration, personal communication, May 23, 1994). Transponder time costs between $300 and $600 per hour, depending on the length of time leased ($600/hour for a one-time use, $400/hour for a weekly lease, and $300/hour for a year lease) (Charles Mellone, personal communication, May 23, 1994). Rates can vary according to the time of day that transmission is occurring.

Currently, it is estimated that only 70-80 percent of C-band and Ku-band transponder capacity is in use (Charles Mellone, personal communication, May 23, 1994). Distance-learning providers have attempted to reduce costs by extending programming to more students. However, this reduces the possibility of synchronous interactivity, a component of distance learning that some deem to be essential. Some distance-learning providers are using alternative technologies, such as "800" hotline telephone numbers, voice mail, and computer networks, to develop asynchronous interactive components that meet learners' needs for interacting with their instructors and peers.

Two promising digital satellite technologies are Very Small Aperture Terminals (VSAT) and Direct Broadcast Satellite (DBS). VSAT systems use dishes that can receive and transmit digitized voice, video (around 15 frames per second, providing limited motion video), and data signals via satellite. VSAT allows multiple channels to be transmitted on a single transponder, in contrast to the single channel of analog transmission. VSAT 56KB dishes, ranging in size from 1.2 to 2.4 meters, with an antenna, outdoor unit, indoor unit, and a cable linking them, cost approximately $12,000 (Carl Girod, personal communication, June 10, 1994). VSAT networks in the United States have grown steadily; the number of terminals has increased from 14,000 in 1987 to 100,000 today (DalBello, 1994). In 1991, 15 percent of community colleges and 33 percent of four-year institutions were using satellites for distance learning, whereas less than 0.5 percent and 1 percent, respectively, were using VSAT (Brey, 1991). Many VSAT data systems are currently used by retail chains to verify credit card information. PBS is in the process of providing each of its 200 licensees with VSAT dishes to be used mostly for business communications among the stations but with potential for being used for distance learning.

In one of the few uses of VSAT at the K-12 level, PBS is sponsoring a VSAT project with a Washington, D.C., school and a San Rafael, California, school. Using segments of MacNeil/Lehrer programming and additional data transmitted to the hard disc drives of computers using VSAT dishes at the two schools, middle schoolers compile information and create their own video programming, using computer-mounted camcorders. The student creations are then transmitted between Washington, D.C., and California (again using the VSAT dishes) and discussed in real time by the students ("PBS's Educational Satellite Network," 1993).

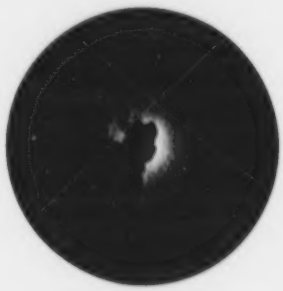
The satellite industry expects that high-powered DBSs that support high-definition television, CD-quality radio, and data services, along with smaller and cheaper receiving antennas, will strengthen the role of satellites in the National Information Infrastructure (NII) (DalBello, 1994). The initiation of DBS services in mid-1994 will provide a means of reaching the most rural sections of the country with multiple channels of television service. Two DBS services, DirecTV and United States Satellite Broadcasting (USSB) will use high-powered satellites and digital video compression to broadcast approximately 200 channels of television programming directly for home and school reception throughout the contiguous 48 states. Schools, homes, and other sites will be able to receive DBS television signals with small satellite receivers that use an 18-inch receiving dish and cost less than $1,000. The program offerings for the 200 channels are expected to include many familiar satellite-cable and broadcast television offerings, including public television, as well as customized special programming services ("The ABC's of DBS," 1993; Stern, 1993). The two-year-old GALAXY Classroom project provides 37 elementary schools in the United States and one in Mexico with original educational programming via DirecTv.

Cable

Cable television systems send a signal over coaxial or fiber optic cable from service providers to subscribers who pay a monthly fee for service (according to the National Cable Television Association [NCTA, 1994], basic service averages $20.75). Coaxial cable, which makes up most of the "last mile" of cable systems, is capable of carrying over 100 video channels transmitted from a local service provider to the subscriber. Compression technologies, which will be implemented by many cable providers in the next year, are expected to increase that capacity by four- or five-fold (Don Dulchinos, Cable Labs, personal communication, June 20, 1994). The signals are decoded and viewed by the user on a television set. Most cable systems are currently operating as one-way video providers, with a minimal capacity for receiving a data stream from subscribers for interactive distance learning or services such as pay-per-view. A return video or audio loop would require reconfiguring the amplifiers and other electronics along the path from the service provider to the user and the use of another channel on the system. Currently, fewer than 10 percent of all cable systems have two-way interactive services—although the coaxial wire in place is capable of carrying the two-way signal, few systems have the electronics in place that are needed (Don Dulchinos, personal communication, June 20, 1994). However, as some systems upgrade their fiber and switching capacity, they are experimenting with offering video-on-demand, Internet, and telephone service. Cable programming comes from a variety of sources, including local commercial and public broadcast stations and regional and national providers. Some localities, when putting the rights to their system out to bid, have required the winning contractor to connect the public schools to the cable system for no added charge.

According to Cable in the Classroom, a public service initiative by the cable television industry, 59 percent of all public and private elementary and secondary schools were receiving cable services in 1993, reaching more than 34 million students. This does not mean cable services in every classroom, but rather, at least one room in the school. Decker Anstrom (personal communication, December 1994), president of the NCTA, projects that by 1995, 95 percent of all high schools will receive cable programming. Analysis of 1993 school statistics by the Nielsen Media Research Group found that 73 percent of all public secondary schools and 66 percent of all public elementary schools have cable television. The percentages for private school are significantly less: 32 percent for secondary and 34 percent for elementary schools. In 1991, 14 percent of community colleges and 22 percent of four-year institutions were using cable television to deliver live distance-learning courses (Brey, 1991).

According to the NCTA (1993b), more than 60 percent of households subscribe to cable programming services; and the services are available for subscription by 96 percent of the homes in the country (this means that a cable service provider has infrastructure within one mile of the home). Over the next 6-10 years, the cable industry estimates it will spend over $14 billion to upgrade 75 percent of its existing systems with state-of-the-art technologies, such as fiber optics (NCTA, 1993a). These changes will enable cable systems to stay at the forefront of increasing channel capacity and using interactive services. Currently, 11,160 individual cable systems serve the country. Of these, 2,280 (20 percent) have less than 30-channel capacity, with approximately 1.9 million subscribers (3.5 percent); 6,364 (57 percent) have greater than 30-channel capacity, with approximately 32 million subscribers (58 percent); and 1,306 (11.7 percent) have greater than 54-channel capacity, with approximately 21 million subscribers (38 percent) (NCTA, 1994, pp. 6-A, 10-A). The lower-capacity systems tend to be located in rural areas with low population density, whereas the higher-capacity systems tend to be located in metropolitan areas. This is likely a function of cost--the fewer channels a system has, the lower its expenditures on licensing fees for programming (Don Dulchinos, CableLabs, personal communication, June 20, 1994).



Some consortia of cable operators in a given

Fiber optics' capacity to provide voice, video, and data signal over telephone and cable networks expands the potential of these networks for education.

state or region (i.e., Comcast, Service Electric, and Berks Cable) are leading the way to interconnecting all local cable *headends* with fiber optic cable (Don Dulchinos, personal communication, June 20, 1994). The regional *hub* and statewide interconnection technology plan has been largely facilitated by CableLabs of Boulder, Colorado, the research and development arm of the cable television industry. This interconnection would serve as a statewide distribution network and enable switching capacity, which will be critical for "on-demand" video services. In addition, interconnection of the individual cable systems provides the potential for using the cable network as a point-to-point communication system comparable to the telephone network. It also facilitates the delivery of distance-learning programming beyond the local loop to other areas in the state or region.

The trend in the cable industry is to install *fiber optic cable* to replace copper coaxial cable. This trend is a result of upgrading, which makes possible some of the new services, such as two-way interactivity, video-on-demand, and voice and data services. Fiber optic cable carries voice, data, and video signals converted into modulated light waves travelling over strands of glass fibers. Fiber has virtually unlimited bandwidth capacity, allowing it to transport tremendous amounts of information. It is currently being used in multiple types of telecommunications systems, including telephone, cable-TV, and data networks.

Fiber cable is a relatively expensive transport system to install because of its fragility (fiber cable can break if it is bent too far) and the necessity to acquire easements to either bury it or hang it on poles (although other wired systems have the same costs). The transmission equipment required to convert voice, video, and data signals into light waves and then back into electronic signals currently is more expensive than the equipment used for other wired systems. However, fiber does allow for multiple signal types to be transmitted simultaneously over long distances without the need for the same level of amplification required by copper or coaxial systems. In addition, its greater capacity than other transport systems expands its potential uses.

The greatest benefits of cable television include its extensive penetration of homes and schools and its ability to carry multiple channels of voice, video, and data signals. Its limitations include the following: 40 percent of the country does not subscribe to cable services; many rural areas do not receive service; and there is a disparity in system capacity and function from cable provider to cable provider.

Telephone

The telephone system in the United States is used for multiple purposes; carrying voice conversations, delivering text data between computers, sending images over fax machines, and transmitting video images on high-capacity lines. Telephones are often used in distance learning for providing a voice link between the instructor and learners. Combined with modems and computers, the telephone system provides a powerful medium for learning through electronic communication. New compression technologies are allowing more and more data bits to be transmitted over the copper wires that make up much of the "last-mile" system.

Education has not extensively used the telephone as an integral part of instruction because, in large part, the system does not extend into the classrooms of this nation as it does into homes and businesses. Almost every home and business in the country has telephone service, with home penetration rates up to a national average of 95 percent (Belinfante, (1993). K-12 schools, however, where approximately 47 million students and 3 million teachers spend the majority of their day, have minimal phone service. A recent survey estimates a 12-percent penetration rate in the nation's classrooms (Princeton Survey Research Associates, 1993).

The FCC regulates interstate and intrastate toll calls. Intrastate local calls, installation, and monthly access charges are regulated by the PUCs of each state. The PUCs in the past have exclusively authorized only two categories of tariffs:

business or residential. The business rate for installation and monthly access in most states is two to three times higher than the residential rate (Organization for the Protection and Advancement of Small Telephone Companies [OPASTCO], 1994). To provide affordable universal service to all homes, telephone companies subsidize the expense of residential service with higher business rates. In most states, educational institutions are charged at the business rate. Some states, such as Texas and Alabama, have recently enacted educational tariffs that allow K-12 educational institutions to pay residential rates for lines that are used for educational purposes.

Frequently, local and regional phone companies exceed the rate of return caps set by the PUCs, resulting in a pool of money that must be rebated to consumers either directly or, with the approval of the PUC, through a public service initiative. Using excess revenues, Rhode Island is currently implementing a three-year pilot project that provides free installation and waives monthly access charges to all K-12 schools in the state. However, the phone lines are only being laid to the building; and schools must bear the cost of taking the lines to the classrooms. The lines can be used only for accessing the Internet or other networks for educational purposes (David LaFrance, Rhode Island Division of Public Utilities and Carriers, personal communication, March 22, 1993). In Michigan, Ameritech has been directed by the PUC to fund distance-learning projects in Michigan schools, using $10.5 million in excess earnings plus another $15.5 million in penalties and interest. Two million dollars will be used to establish a Michigan government television channel, similar in style to C-SPAN; and the remaining funds will be disbursed to schools, based on proposals submitted to the Michigan Council on Telecommunication Services for Public Education (*Heller Report*, 1994b).

The existing infrastructure, which delivers to homes, businesses, and schools local telephone service provided by the seven Regional Bell Operating Companies (RBOCs) and by more than 1,100 independent phone companies, consists almost entirely of twisted-pair copper wiring. This is a narrow-band conduit with limitations concerning quality and quantity of transmission of advanced digital services. Recent advances in digital compression technologies have resulted in three developments that allow for advanced services to be carried on copper wire: integrated services digital network (ISDN), asymmetric digital subscriber line (ADSL), and high-bit-rate digital subscriber line (HDSL).

ISDN technology transports a digital signal carrying voice, video, or data through the copper wires of today's telephone system. By the end of 1994, it is estimated that almost 60 percent of the nation's telephone access lines will be connected to the digital switching infrastructure needed for ISDN. ISDN can deliver greater interactivity than ITFS or satellite delivered programming, with no added cost to the program (Electronic Frontier Foundation [EFF], 1993). A major test site for ISDN applications to education is currently being operated in North Carolina by Appalachian State University (ASU), AT&T Network Systems, and Southern Bell. The Impact North Carolina: 21st Century Education project's ISDN network delivers interactive video instruction, access to library resources, and professional development programming to elementary and high schools, community colleges, and ASU.

Although ISDN does not offer the speed or capacity of broadband networks, its affordability and the use of infrastructure already in place make it an appealing transition to universal broadband services (EFF, 1993). ADSL and HDSL offer greater broadband capacity than ISDN, capable of delivering full-motion video along with data and voice services.

Whereas most of the local infrastructure is copper wire, most of the long-distance network operated by AT&T, MCI, Sprint, and other smaller carriers is primarily fiber optic cable. Fiber's high capacity allows long-distance companies to carry heavy traffic over a single *backbone* cable that delivers the signal to local or regional switching stations. Although the broadband capacity of the backbone can be used to

transport voice, video, and data simultaneously, a problem arises when the broadband signal attempts to enter the local copper-based infrastructure. It is similar to splicing together a fire hose and a garden hose—as water travels from the fire hose to the garden hose, the volume of water per second that exits the garden hose is greatly reduced over the initial flow rate.

Corning, a major manufacturer of fiber optic cable, estimates that at reasonable substitution rates of fiber cable for copper wire, 93 percent of all U.S. schools, offices and households by the year 2035 will be served by broadband networks at no extra cost to telephone ratepayers. Corning bases its estimates on the average annual expenditures by telephone companies of $18 to $20 billion on building, maintaining, and rehabilitating existing copper telephone lines. If the telephone companies maintain this investment rate, by 2015 the approximately $430 billion spent will almost equal the $450 billion estimated by the Consumer Federation of America to create a fiber network covering the United States. Corning estimates that the United States can achieve the goal of universal deployment by 2015 for an incremental cost of $23 billion (1992 dollars), or 70 cents per telephone subscriber per month for the next 20 years (Suwinski, 1993). One of the disadvantages of using fiber in the telephone system is that unlike copper, fiber requires a separate power source for operating the communication devices. Therefore, when power outages occur, communications will be contingent upon users' abilities to locate separate power sources (i.e. batteries or generators).

The RBOCs have all released statements emphasizing their commitment to providing educational institutions with access to the NII. Pacific Bell recently announced a $100 million initiative to provide every classroom and library with the wiring necessary to access voice, video, and data services. Bell Atlantic is moving forward with its Basic Education Connection, which promises to bring voice and data services to every classroom in its region by the year 2000. One of the critical factors that may influence the RBOCs' commitment to extending the nation's communications infrastructure into the classroom is the FCC's impending ruling on how excess long-distance, price-cap revenues must be distributed. The price-cap revenues are a potential funding mechanism for the RBOCs to use without having to raise prices or seek a government tax to pay for building the infrastructure.

Microwave/ITFS

Two types of microwave technologies are now being used. Point-to-point microwave transmission is a transport system that uses part of the radio spectrum to send either digital or audio signals between antennas mounted on towers or buildings that are usually located from 5 to 40 miles apart and within line of sight. It has the capacity to carry voice, video, and data signals. Point-to-point microwave is usually used as part of a transport system to carry a signal without burying or hanging wire, or in small (2- or 3-site) networks for voice, video, and data transfer (U.S. Congress, Office of Technology Assessment [OTA], 1989).

The second type of microwave transmission, Instructional Television Fixed Service (ITFS), uses microwave transmission in a broadcast mode, although it has a more limited range than standard broadcast television. ITFS offers an audio return channel but limited capacity for a return video signal, although compression technologies are capable of realizing that possibility. ITFS transmission equipment costs between $20,000 and $30,000 per channel, compared to $80,000-$100,000 for a satellite uplink. A receive antenna capable of receiving simultaneously up to four channels costs around $150 (Leveille, 1992).

The FCC originally set aside microwave frequencies for ITFS in 1963 to be used exclusively for educational and cultural programming. It has been applied extensively across the United States, especially at the higher-education level. For example, ITFS is in use at 16 of 20 California State University campuses, with more than 250 receive sites throughout the state (Leveille, 1992). In the 1980s, the FCC reallocated an unused portion of

the ITFS spectrum for commercial use, creating a flood of commercial entrepreneurs who have quickly filled the spectrum. In many major metropolitan areas, it is now difficult for educational institutions wishing to use ITFS to acquire the needed spectrum. Commercial interest in ITFS has risen since the FCC reallocation. Private wireless cable providers, anxious to increase their channel capacity, have developed partnerships with educational institutions, in which ITFS hardware is provided free to the schools. The wireless cable company, in turn, is able to lease some portion of the four channels allotted per license. According to Theodore Steinke, Chairman and CEO of the National ITFS Association (personal communication, June 13, 1994), other community partnerships allow educational programming during certain times of the day and commercial programming for the remainder.

Because the broadcast range of ITFS is limited to less than 50 miles, it is more predominant in urban rather than rural districts. The line-of-sight requirements make mountainous regions less suitable for ITFS (Wayne Coy, Cohn and Marx law firm, personal communication, June 13, 1994). The ongoing operational costs of providing ITFS services are lower than satellite, as there are no additional charges for ITFS "air time." (Leveille, 1992).

Wireless

New and emerging wireless communications technologies, such as direct broadcast satellite (DBS), broadband radio services, personal communications services (PCS), wireless local area networks (WLAN), and advanced television (ATV), offer the potential for integration into future technology and telecommunications applications in learning and training, with the flexibility of not being tethered to outlets when using communications units such as telephones, fax machines, and computers. Research and engineering studies are being conducted by NTIA's Institute for Telecommunication Sciences to take laboratory and field measurements of advanced wireless communications technologies to help develop and introduce innovative communication systems, including enhanced educational delivery systems.

Cellular mobile communication systems are currently being provided by telephone companies. Increased competition and lower computing costs have resulted in cheaper prices for mobile telephony. Telephone companies expect that advanced digital cellular technology will eventually be as cheap as wireline telephony. Digital cellular technology has the potential for facilitating mobility among computer network users. Some laptop computers already work with wireless modems to transmit and receive data. Some proponents of wireless see it as a viable, inexpensive alternative to fiber for the "last link" of existing communications networks. Potential obstacles to wireless communications involve spectrum availability ("The End of the Line," 1993).

Cellular technology is being used to deliver video signals over short distances. In Brooklyn, New York, "CellularVision" provides subscribers with cable channels by using a six-inch antenna to pick up programs from a microwave transmitter about a mile away. This is a potential solution for combining the resources of broadcast and cable with the local versatility of ITFS. According to CellularVision, a different sort of receiver can provide interactive TV, data transmission, telephone, and voice and video conferencing using the same system. The company's system is based on the same technology as traditional cellular telephone networks, but uses much smaller cells, within a radius of a few miles. The transmitter operates at a low power; but because it operates at high microwave frequencies, it can transmit with a surprisingly wide bandwidth. For crowded urban schools, this type of wireless communication could provide efficient "last link" service without having to wire an entire building ("The End of the Line," 1993).

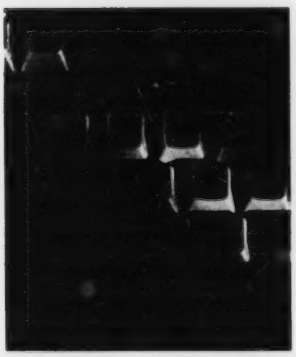
It is expected that wireless technologies will greatly facilitate delivering the NII to learning sites and to rural and inner-city areas lacking wired telecommunications infrastructure. The wiring of some schools, especially older buildings with thick

Wireless technologies may make it easier to deliver the NII to rural and urban learning sites that lack telecommunications infrastructures.

walls and possibly even asbestos, could prove to be prohibitively expensive. In addition, the limited sturdiness of physical connectors to withstand frequent connections and disconnections, as students take tablet-sized computers from class to class, could require frequent repairs. Wires also constrain desks and work areas to fixed locations, and may clutter the classroom environment. The wireless network would overcome these problems by allowing a single wire to be used to connect the wireless network port in each classroom at significant cost savings.

Computer Networking

Multiple technologies are often combined to form a computer network that delivers data, as well as video signals for distance learning. Accessing information and communicating with electronic mail are the primary applications of computer networking for distance learning. An array of systems, including both wired and wireless technologies, are used to connect computers situated within the same building or across the country. Computer networks allow learners to communicate with each other and with available resources by transferring information across distance. Such networks facilitate asynchronous interactions among learners, teachers, and service providers. They encourage collaboration and learner participation, easing the constraints of time by allowing users to customize time frames for thoughtful discussion and response (Mason, 1988; Moore, 1989; Phillips & Santoro, 1989). Some research suggests that using networks may improve skills involving written communication and the organization of ideas (U.S. Department of Education, 1993). Networks can exist internationally, as do the Internet and K12Net, or locally, within a school system or community.



Networks vary greatly in size, scope, and means of transport. Access to a network may occur through ordinary twisted-pair telephone lines; higher-capacity lines, such as T1, T3, or fiber optic cable; or even through microwave or satellite transmission. A network usually has a hub or *server*—a computer dedicated to managing the flow of data between computers on the network. Typically, a user's computer is connected to a network through a *modem*, a device that converts analog and digital signals into text or graphics that are viewed on the computer's monitor. Modems are relatively inexpensive, varying in price according to transmission speed. A 9600 baud (bits per second) modem can now be purchased for under $100, while a 28.8K baud modem costs approximately $500.

The *Internet* is a "network of networks," an electronic pathway for data to travel across the country or around the world. There is no central computer or controlling agency that manages traffic or dictates rules. In many ways, Internet's anarchical structure is both a blessing and a curse (Lewis, P. H., 1994). Advanced users of the system praise its open architecture and the freedom of creativity and expression that stems from the lack of oversight by any public or private censoring groups. Critics of the system cite the lack of structure and oversight as a hindrance to novice and intermediate users who have trouble navigating their way through cyberspace. Teachers, in particular, have complained about the complicated procedures that must be followed to access the Internet (National Coordinating Council for Technology in Education and Training [NCC-TET], 1994). New directories, graphic driven menus, and search tools that are being developed will help users determine what information is available and how to navigate a pathway to a particular source.

Educorp's "Networks Now" survey reports that 38 states have either fully or partially operational networks for instructional services. Ten states reported proposed or planned networks with pending legislation, and one state had no current plans. Twenty-nine states provide educators E-mail access to the Internet, and 20 provide E-mail, file transfer, and telnet access. Composite estimates for the number of users of these *state networks* was reported at over 167,000. With the current growth of networks and Internet connections, the number of users of state networks could reach over 1 million by 1995. Budgets for the state

networks ranged from $50,000 (New Mexico) to $5.3 million (Florida) (Kurshan, Sherman, & Frazier, 1993).

Local area networks (LANs) connect individual machines as a network composed of any number of computers, printers, file servers, CD-ROMs, modems, and fax machines, allowing all of the devices to share digital information. LANs are capable of supporting communication between what were once incompatible hardware brands and models such as Macintosh and IBM-compatible computers. According to 1993 Market Data Retrieval (MDR) research surveys, approximately 40,080 public schools own LANs (49 percent). MDR also projects that 75 percent of all districts will be using LANs by the close of the 1993-94 school year and nearly 100 percent by 1998-99.

Table 1 shows that the number of schools using both internal and external networks also has been growing quite rapidly since 1989. Nonetheless, as Table 1 also suggests, the majority of the schools with LANs are not connected to wide-area or external networks, which would be required to support distributed multimedia distance learning (Newman, Bernstein, & Reese, 1992; Pea, 1994).

The EDUCOM-USC study found that 58 percent of higher education institutions reported a campus backbone network. Of these, 56 percent were fiber optic, 30 percent ethernet, and 12 percent were twisted pair. All institutions with a backbone reported having either an Internet or a Bitnet connection. About half (48 percent) of the institutions had Internet access; however, only 36 percent reported such access for undergraduates, and only 25 percent said that undergraduates used the Internet.

Computers facilitate the electronic storage, retrieval, and computation of information and are often used as tools for accessing electronic networks. Based on recent surveys by the International Educational Assessment (IEA) and the Software Publishers Association, an estimated 4.5 million computers exist in American schools (Anderson, 1993). According to the *Computers in American Schools 1993* study done by IEA, since 1982 the number of computer units in elementary and secondary schools in the United States rose each year by a net increase of 300,000-400,000 units (reflecting discards as well as acquisitions). Between 1989 and 1992, schools added 1.1 million units, increasing their inventory by almost 50 percent, from 2.4 million to 3.5 million computers. Growth was fastest at the upper secondary level.

Table 1
PERCENT OF SCHOOLS REPORTING
USE OF INTERNAL AND EXTERNAL NETWORKS, 1989-1992

Grade Level	1989	1990	1991	1992
Elementary				
Internal (LANs)	8			26
External	-			23
Lower secondary				
Internal (LANs)		17		28
External	-		22	
Upper secondary				
Internal (LANs)		23		41
External	-		34	

Note: LAN = local area network.

Source: Ronald Anderson, personal communication, 1994. See also: Anderson, R. E. (Ed.) (1993). Computers in American schools, 1992: An overview. (IEA Computers in Education Study). Minneapolis: University of Minnesota, Department of Sociology (909 Social Sciences Building).

The total computer inventory in high schools increased by 57 percent, compared to an increase of about 41 percent in elementary and lower secondary schools. The "typical" high school (i.e., the high school with the median percentage gain) increased its inventory by nearly one half (47 percent) whereas the typical elementary or lower secondary school increased by one-third (32 percent) (Anderson, 1993).

Student-computer ratios (the number of students enrolled in a school divided by the number of computers available for students to use) measure how likely students are to have access on-demand to a school computer. The

33

U.S. median student-computer ratios based on entire school enrollments are 15:1 for elementary, 14:1 for lower secondary, and 10:1 for upper secondary schools.

Estimates of the number of college and university computers are rough because few institutions have a current inventory of computers. In addition, many faculty and students bring their own computers on campus, which probably would not be indicated in a survey. A survey conducted by EDUCOM-USC obtained estimates on the "number of desktop computers used on campus," and on this basis concluded that in 1991 there were about 2.6 million units (Oveen & Eastman, 1992).

Table 2
Educational Attainment of Computer-Using Workers

Highest Educational Attainment	Percent Using Computers at Work
Not High School Graduate	8.36
High School Graduate	29.81
Some College	50.00
Four Years of College	59.55
More than Four Years College	59.88
Total	38.31

Source: U.S. Department of Commerce, Bureau of the Census. (1989, October). Current Population Survey. Washington, DC: U.S. Government Printing Office.

Good estimates of computer use in adult education programs are unavailable (Anderson, 1993). A recent report published by the Office of Technology Assessment (OTA) (U.S. Congress, 1993) reported, however, that fewer than 15 percent of adult literacy programs use computers regularly in instruction.

According to the U.S. Bureau of the Census, almost 40 percent of U.S. workers use computers in the workplace. There is some indication that workers with more education are more likely to use computers in their jobs (see Table 2) (George, Malcomb, & Jeffers, 1993).

Integration of Technologies

The technologies described in this report are rarely used in a discrete context for distance learning. Rather, multiple technologies are integrated into delivery systems or networks. This trend is being facilitated by the widespread use of digital information, which can be more easily transferred between technologies than the standard analog signals. In addition, because each technology offers unique technical, capacity, or cost benefits, the market is demanding an aggregation of these benefits in distance-learning systems. Combining voice, video, and data into one service does not mean that the service must be delivered using one technology. For example, much excitement exists over the speed and capacity of fiber optics. Indeed, fiber optic cable will play an essential role in delivering distance-learning services and other services on the NII, but there are important roles for the other delivery technologies as well. Integration of technologies is occurring at two levels: delivery systems that transport voice, video, and data signals across distance; and interface units that allow the user to access and transmit signals.

Implementation and integration of various technologies for distance learning and the NII will occur at the federal, state, and local levels and in the private sector. The needs of users and providers and the resources available for implementation vary from home to home, school to school, business to business, community to community, state to state, region to region, and even from nation to nation. Some of the variables that determine this variance include cost, compatibility with previously purchased equipment, geographic impediments (i.e. mountains), distance between the provider and users, number of system users, necessity for monitoring use (for billing and security), and other considerations.

The use of various technologies in distance learning include computers, televisions, VCRs, telephones, fax machines, voice mail systems, computer bulletin boards, and other machines or systems that allow learners and teachers to access, transmit, store, analyze, and compute information. These interfaces, which initially were

designed to perform a distinct task, are continuing to evolve to perform multiple tasks involving information in voice, video, and text formats. For example, computers now not only compute and process numbers and text, but also display video, provide access to information networks, and store voice mail. But even when a technology supports only one function, the current trend in distance learning is to integrate as many of the technologies as necessary for providing interaction and support to learners.

Many distance-learning programs are already using a mix of technologies to best serve their learners. In 1991, community colleges engaged in distance learning reported using an average of 3.7 different technologies for delivery and reception, with an expected growth to 5.6 technologies in 1994. Four-year institutions averaged 3.4 different technologies, growing to 6.1 technologies by 1994 (Brey, 1991).

Many service providers that in the past have transmitted their programming using a primary technology, such as satellite, broadcast, or cable, are moving toward an integrated delivery system. PBS, which traditionally has operated in the broadcast mode, is planning to use multiple delivery systems as they become available and cost-effective. PBS has stated:

> In terms of our own industry infrastructure, satellite is clearly the only universal system, and, because of compression, it's becoming extremely cost-effective. So, for our first mile in reaching our stations across the country, and also taking advantage of the fact that many schools today have satellite dishes—many of them are in areas where there is no cable—we certainly want to use the existing, available technology. But we're already looking at ways that the new fiber network, whether it's owned by the cable companies or the telcos, can be extremely helpful to us in the last mile ("PBS's Educational Satellite Network," 1993, p. 38).

Following are some examples of how technologies are being integrated to better deliver distance-learning services to learners:

- Satellites are currently used to distribute cable television to local providers. Cable systems receive satellite programming, which is then sent over the cable system to the school.

  In Vermont, the Regional Educational Television Network (RETN) uses three cable companies to link nine schools districts serving almost 20,000 students at all grade levels. The districts act as a collaborative to purchase programming from instructional networks—programming that each school district acting as an independent agent may not have been able to afford. For example, RETN pays the Massachusetts Corporation for Educational Telecommunications a $5,000 fee for programming that serves the entire collaborative, a savings of $40,000 if the programming were purchased individually by each district. RETN is planning to add a second channel to each of its school districts, allowing the individual districts to provide local-interest programming, such as school plays or meetings (Smyle, 1993).
- Fiber is currently being used by all of the local and long-distance telephone companies and by many of the cable companies nationwide. It is used mostly as a trunk carrier, receiving and delivering signals fed by either copper wire or coaxial cable. One of the advantages that coaxial cable offers is that it provides a broadband capacity similar to fiber at distances under 300 feet. With over 60 percent of the nation's households and 70 percent of the nation's schools already wired for cable, an integrated fiber/coaxial network could be much cheaper than deploying fiber to every home and classroom.

  An example of the fiber/cable model has been tested in Indiana. The Indianapolis Regional Economic/Academic Development (IREAD) network is a closed-circuit television system operated since 1992 by Indiana Bell/Ameritech, Thompson Consumer Electronics, and Indianapolis Public Schools (IPS). Indiana Bell connected a 600-mile, fiber optic trunk line to 3 administration buildings, 87 schools, and Indiana University-Bloomington. Many of the schools were already wired for cable and

Multiple technologies are usually integrated in distance-learning delivery systems.

were connected to the network using the existing coaxial infrastructure. The network offers voice, video, and data services at a cost of $15,000 per month to IPS (Lewis, J., 1993).

- ITFS serves as a redistribution system in some states, retransmitting satellite, cable, and other signals for broadcast microwave reception. In Detroit, Michigan, the Community Telecommunications Network (CTN) is serving approximately half of the schoolchildren in the state with video programming. CTN operates an ITFS transmit tower north of Detroit that is capable of broadcasting 32 channels up to 50 miles. CTN's Technical Operating Center (TOC) transmits programs originating from videotapes, received by point-to-point microwave, from Michigan Bell's fiber network, or from a Ku/C-band satellite dish (Leveille, 1992).
- The San Marcos Telephone Company of Texas has deployed fiber optic cable to connect three sites near Austin: San Marcos High School, the Gary Job Corps Training Center, and Southwest Texas State University. Although the system is fiber based, it has the capacity to incorporate the telephone, satellite, microwave, and cable systems. Called the TeleCommUNITY Network, the system provides video, voice, and data services not only to students but to members of the community who are enrolled in literacy, adult education, work-skills training, and college-level courses that meet after normal school hours and on weekends. The distance-learning network allows learners at the three sites to take advantage of the combined human and technological resources of all the institutions (Corning, 1993).
- Maine is currently operating a statewide community college system completely using distance-learning resources. Because of the difficult winters and dispersed population, the state decided to deliver two-year associate degrees using a system combining video, audio, and data services delivered to students at learning sites and in their homes. A fiber backbone connects the state colleges and delivers programming to ITFS transmitters that broadcast to learning sites. Audio bridging through NYNEX (a telecommunications system in New York and New England) allows students to interact with the instructor and students at other sites. Computer conferencing and on-line data services are also available (Mayor, 1994).
- The GALAXY Classroom project delivers video by direct broadcast satellite via DirecTv, data and voice transmissions are sent and received by 2-way VSATS, student interaction with the televised "instructors" is accomplished by fax, hands-on learning experiences are provided by accompanying activity kits, and teacher preparation is provided by supplementary print materials. Plans for the 1994-95

Figure 2
Example of CNN Classroom Materials

ANCHOR DESK December 14, 1993
(2) TOP STORY RUSSIAN ELECTIONS

1. How do the initial results of the Russian election indicate feelings in the country about economic and social reform? Discuss actions President Yeltsin may choose to take if a Russian parliament predominantly opposed to reform is elected.
2. How can the vote be portrayed as a yearning from the electorate to return to Superpower status? Group students and assign to each group a decade in the 20th Century. Have each group
a. Research their decade from the Russian point of view, noting what happened in Russia and how changes in Russia influenced world events.
b. Cooperate in writing a series of newspaper headlines, a diary or even a simple dialogue play, fictitiously based on the experiences of a Russian swept up in those events. Have each group perform its work for the class in chronological sequence. Then discuss:
How might the cumulative experiences of the Russian people through the 20th century generations have culminated in Sunday's election results?

RUSSIAN ELECTIONS—WORLD REACTION
3. How might the composition of the new Russian parliament affect international policies toward integrating Russia into the world community? Discuss . . .

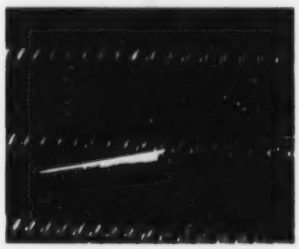
school year include addition of Internet E-mail to enable student interaction with computers.

Once the basic equipment—antenna, receiver, TV monitor, and phone line or E-mail for student interaction—has been acquired; schools can set up GALAXY networks according to their needs and facilities. Options include: designing a school hub with classrooms connected to a central computer and with an ethernet network; establishing a media or resource-room connection with a hub computer and a fax machine (or computer for E-mail); or a single monitor and fax machine hooked to a dedicated phone line. According to program materials, equipment costs are estimated at $2,600 per classroom, with an additional $9,950 for the school hub design and $6,500 for the media room design. The single-classroom model does not require additional hub costs, but does require the school to pay monthly phone charges for student fax interaction. According to GALAXY, agreements can be negotiated to rebroadcast the signal in Ku- or C-band uplinks or to use local cable wiring. Subscription costs per student are expected to be comparable to textbook costs, though rates have yet to be finalized (according to materials received from Galaxy Institute for Education, June 1994).

The project offers science and language arts programming to elementary schools nationwide. Current offerings include language arts and science, with mathematics, social studies, foreign languages, and arts programming under development. An independent evaluation of the language arts program concluded that the program, while reaching "diverse multicultural learners in a way that generated extraordinary student enthusiasm," resulted in reading and vocabulary improvements that were significantly greater than in comparable classrooms (Clifford, Guth, & Austin, 1993).

Following are some examples of how user interfaces are being integrated to better deliver services to learners:

- One of the greatest challenges that video-based distance-learning providers and users face is finding a common time that learners and teachers from across the country can participate in a lesson. If interactivity is a desired component, the challenge is expanded. Using VCRs, programs can be recorded for later viewing. This has been especially useful in schools where schedules are difficult to adjust. For example, Ken Burns' (1990) award-winning documentary on the Civil War, an excellent resource for U.S. history classes, originally was broadcast nationally during the evening. The VCR provided teachers with the ability to record the show and incorporate it into their classes when they were ready to use it. Interactivity can be incorporated into recorded programs by establishing "hotlines" that students and teachers can call with questions or using computer bulletin boards for exchanging information. This asynchronous mode of distance learning is becoming increasingly common.
- Interactive video-based programs often use an audio bridge, an operator-assisted telephone line that allows viewers to call in and be connected to the instructor. Cordless phones are frequently used at the receive site so that the phone can be easily and quickly passed to students around the classroom.



PROVIDERS OF DISTANCE-LEARNING RESOURCES

Distance-learning resources consist primarily of video programming (live instruction and prerecorded) and information services (databases). The providers of these resources range from multistate, nonprofit consortiums to independent producers to for-profit information services.

Following is a description of some of the major distance-learning providers:

- The Agricultural Satellite Corporation (AG*SAT) is a four-year-old consortium of land-grant institutions, government, and business and industry. The organizations work together to provide educational services via

satellite for agricultural producers, rural families, and businesspeople, many of whom are in remote or resource-poor areas. Participating offices and institutions are also linking into the Internet computer network, strengthening communication capabilities. Areas of instruction include livestock and crop management, marketing and accounting, child care, nutrition and leadership training, and developments in agricultural research. The combined satellite/computer network has also been instrumental in delivering disaster-relief information quickly and efficiently. AG*SAT's network is made up of campuses and Extension Centers nationwide, usually in rural areas or geographically remote cities, and a Satellite Operations Center at the University of Nebraska. A total of 12 uplinks and 31 receive dishes have been installed, with another 3 uplinks and 178 receive sites planned or under construction. Funding for AG*SAT has been provided by three grants totaling $1.735 million from the U.S. Department of Commerce Public Telecommunications Facilities Program (PTFP) and matching grants from member institutions, local agencies, and states (Randy Brez, AG*SAT Headquarters, personal communication, June 1994).

- The Black College Satellite Network (BCSN) provides programming for pre-K through grade 12 and higher education learners and professional development inservice programs for teachers and administrators at all levels. BCSN services 23 states, the District of Columbia, and the U.S. Virgin Islands and has installed more than 1,000 receive dishes nationwide. BCSN is working in partnership with the Central Educational Telecommunications Network (CETN) to deliver programming for the U.S. Educational Network (USEN), a collaborative effort by four major urban school districts (New York City, Philadelphia, Dallas, and Washington, D.C.) to deliver high-quality educational opportunities using shared resources.

  BCSN has trained students and staff at eight historically black colleges and universities (HBCU) to produce video courses for use at the higher education, elementary, and secondary levels. BCSN serves as the distributor for most of the programming produced by the network of HBCUs. During the 1992-93 school year, 20 courses per semester were offered in science, math, and language, totaling about 30 hours of programming per week. An additional series of professional development courses for teachers was offered each semester.

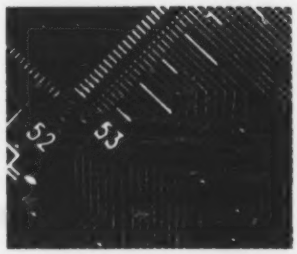
- Cable in the Classroom estimates that during the 1993-94 school year, it has invested $86 million in U.S. schools, including free cable installation to schools and basic service at no cost. Each month, the service provides 525 hours of commercial-free programming available to schools. The programming is donated by over 25 cable networks, such as CNN, Discovery Channel, Lifetime, Mind Extension University, and the Weather Channel.
- The Cable News Network (CNN) Classroom provides daily program guides for their broadcasts over several electronic networks, including gopher, E-mail, and newsgroup feeds. Teachers can read the daily classroom guides, which list the top stories, vocabulary words, handouts, and questions for further discussion. The service is free and exemplifies a basic form of educational multimedia.

  Figure 2 shows an example of the types of support materials supplied by CNN Classroom for use with their daily video broadcasts.

- The Community College Satellite Network (CCSN) is a member-driven coalition of community colleges and educational affiliates serving the needs of its members through the cooperative use of satellite technology. It has been a division of the American Association of Community Colleges since 1989. CCSN offers members a variety of services, including discounts on teleconferences for faculty/staff development, lifelong learning, and continuing education; assistance in

marketing, producing, and coordinating teleconference productions; resources on distance learning technology and information; and participation in a nationally coordinated teleconference downlink network for use by fellow educators, business, government, and community members. Through its activities in coordinating teleconference downlink sites at community colleges, CCSN is attempting to establish a "satellite information infrastructure." Government, business, and industry are using this network to deliver training and information programs via satellite to rural and urban communities throughout the United States (Monica Pilkey, CCSN, personal communication, January 1995).

- Homework Helper is an educational, on-line database service, planned for launch in February 1995. The database will include a vast array of information, including full-text encyclopedias, almanacs, dictionaries, and thesauruses; national and international news wires; full-text newspapers, consumer magazines, "great works of literature," and study guidebooks; standardized exams and tutorials, maps, photographs, and graphics libraries; and basic reference works, including book reviews, movie reviews, and periodical abstracts and indexes. According to Infonautics, its developer, the service will be easier for students to use than some existing services. Rather than rely on Boolean searches or traditional database access languages, users will be able to enter a query in "plain English" and receive bibliographies of relevant resources. The service is expected to be offered to personal computer users through existing network providers, such as Prodigy, for a price of around $10 per subscriber per month. Infonautics suggests that the Regional Bell Operating Companies may begin to offer the service as one of their initial information services. The capacity for localization is an expected benefit to school systems, who will be able to incorporate local materials—such as local newspapers and school curriculum materials—into the service (Patricia Kennedy, Infonautics Corporation, personal communication, June 1994; "An On-Line Library," 1994).
- K12Net is a loosely organized, totally decentralized network of school-based, electronic bulletin board systems throughout North America, Australia, Europe, and Russia, which share curriculum-related conferences or echo forums, making them available to students and educators at no cost and usually on a local phone call. Each system on the network is locally owned and operated, but has access to international telecommunications designed to promote literacy, a global perspective, and competency in 21st century information technologies. In 1990, K12Net projects included a *Holiday Cookbook*, a Weather Project, a "Top Ten" List, a Rivers Project, and the Physics Olympics. Other ideas have included acid rain studies across the continent, market comparisons, role-playing games, and many others.
- KIDLINK is a global program that aims to involve children 10-15 years of age in an international dialogue. In its first two years alone, 6,200 kids from 45 countries participated. The focus is on the actual dialogues between the participants and on how others can join the action. KIDLINK has made available a gallery of digitized artwork from children around the world. The services of KIDLINK are provided free of charge. Global communications projects can influence children's motivation to learn about languages, other cultures, geography, current affairs, environmental awareness, computers, writing skills, word processing, global awareness, history, science, and how participants can virtually travel anywhere they please using networks. A novel-like book is planned for publication based on KIDLINK projects and communications.
- The Massachusetts Corporation for Educational Telecommunications (MCET), chartered in 1982 by the state legislature to bring distance learning to a broad constituency within the state, now serves thousands of learners in more than 37 states with high-quality



Distance learning is being used at all levels of education and instruction, from preschool to worker training, but its use is neither well documented nor comprehensively evaluated.

instructional programming and support resources. Working with partners in education, business, government, and other fields, MCET operates programs that cover the full spectrum of education:

Mass LearnPike: Mass LearnPike, the centerpiece of MCET's program, is a satellite broadcast network dedicated to improving the quality of K-12 education by expanding curriculum offerings for students and professional development opportunities for teachers. MCET provides member school districts with a steerable, programmable satellite dish, a 27-inch monitor, a VCR, and a portable cordless telephone. It also airs 75 interactive programs that provide instruction in science, mathematics, social studies, geography, history, foreign languages and cultures, dance/music, and literature. Programs are transmitted as one-way video and two-way audio, complemented by hands-on curriculum materials and suggested follow-up activities that have been designed to transform passive viewing into active participation and learning. With the support of local cable operators, Mass LearnPike programs and services now reach more than 325 communities in Massachusetts and schools in 37 other states.

Mass LearnNet: Mass LearnNet is a computer network dedicated to improving communications among educators in Mass LearnPike member schools. The system was designed to be easily accessible by the range of computers now in schools. It is used for sending electronic mail, submitting telecourse registrations, working on joint projects, and continuing conversations initiated during interactive teleconferences. LearnNet also provides a gateway to the Internet, offering access to national and international databases, discussions, and resources. Technical support is provided for users through videos; live broadcasts; hands-on workshops; and on-line, print, and telephone assistance.

The Learning Community: MCET operates The Learning Community (TLC) Project under a two-year, $4.6 million grant from the Star Schools Program sponsored by the U.S. Department of Education. The project, which operates in three demonstration sites—Boston, Hartford, and New York City—uses multiple technologies to promote mathematics, science, and literacy education among children and adults. Through a partnership program, TLC brings schools together with community organizations, human service agencies, local businesses, technical assistance providers, and cable public access stations.

Higher Education Consortium for Distance Learning (HEC): HEC consists of 24 Massachusetts institutions of higher education, both public and private, working collectively to apply advanced technologies to make education more effective. Members have the benefit of sharing courses, teleconferences, and other resources. They also have access to Mass LearnPike for offering programs targeted to K-12 students and faculty and for providing continuing education to industry and the communities they serve. The 1993-94 Mass LearnPike schedule includes 11 HEC programs.

- Mind Extension University (ME/U) provides fully accredited college and graduate-level courses and degree programs via cable television to approximately 25 million households, with plans to expand to 50 million households by 1996. ME/U also cablecasts live, interactive courses for credit at the K-6 level five days a week. ME/U is the only 24-hour cable network delivering distance-learning programming 24 hours a day. Professional development (certification or recertification) is offered.
- National Technological University (NTU) was founded in 1984 to serve the educational needs of highly mobile engineers, scientists, and technical managers. NTU is a consortium of 45 leading engineering schools that provide graduate courses from their respective campuses via instructional television. The majority of NTU students are working professionals, sponsored by their companies. In the past year, NTU enrolled more than

5,000 students in for-credit courses and 100,000 in noncredit courses.

NTU offers courses under several different plans. Programs leading to the Master of Science degree are offered in 11 areas, including computer engineering, hazardous waste management, and health physics. A certificate program is available for students who wish to design their own courses of study to meet specific career needs. NTU also provides a satellite network infrastructure between industry and the university community and offers a videotape instructional service internationally. Courses in the credit sequence are taught by the top faculty of participating institutions. Noncredit courses, symposia, and teleconferences come from a variety of sources, including universities, industry, and other providers.

NTU is not only an accredited university; it is also the world's largest digital television broadcast network. It delivers over 800 graduate courses and continuing education courses by satellite each year via 38 uplinks and 275 downlinks. In 1992, NTU broadcast approximately 23,000 hours of credit courses and 3,000 hours of noncredit courses to 525 sites, including 99 interconnected network sites.

NTU's distance courses soon will be able to take advantage of full integration of video, data, text, and graphics. In the not-too-distant future, NTU's president, Lionel Baldwin, envisions NTU providing individualized instruction delivered directly to the workstation (compiled from materials received from Donald Coffin, NTU).

- PBS distributes its programming to over 300 public television (PTV) broadcast stations around the United States. PBS broadcasts educational programming for younger learners includes *Sesame Street*, *3-2-1 Contact*, *Mister Rogers' Neighborhood*, and a multitude of documentaries on history, science, the arts, and politics. PBS's other video offerings include K-12 Learning Services, Adult Learning Service (ALS), Adult Learning Satellite Service (ALSS), and the Business Channel. PBS is in the process of introducing or testing several computer-based services, including PBS Online, ALS Online, PBS Learning Link, PTV Online, and PBS Mathline.

PBS has been using satellites since 1978 to relay its signals to its stations and regional networks that broadcast it for open-air reception in their areas. AT&T's launch of Telstar 401 in early 1994 tremendously expanded PBS's capacity to use satellite technology. PBS owns six transponders on the satellite, which with digital compression can carry up to 60 channels. In addition to delivering PBS's package of educational programs (K-12 Learning Services, Adult Learning Service, Adult Learning Satellite Service, and the Business Channel), the satellite provides service for South Carolina Educational Television (ETV), Georgia Public Television, Louisiana Public Broadcasting, National Technological University, Satellite Educational Resource Consortium (SERC), and Satellite Communications for Learning Association (SCOLA). PBS will be offering an array of new video services through Telstar 401 later in 1994, all of which will be supported by PBS Online, a satellite-based computer communications network (*Heller Report*, 1994a).

To take full advantage of these services, many PBS stations and other downlink sites must retrofit their equipment to receive the compressed video signal from the satellite. PBS anticipates a two-year window before it can put some of its programming, such as the Adult Learning Service, which is downlinked by almost 2,000 colleges, into the compressed format because of the colleges' need to acquire the compression equipment. The compressed programming will allow for greater capacity on the transponders. Currently, because much of the transmission is still analog, no capacity is available. As more of its programming is delivered in compressed digital format, PBS will be able to carry more channels ("PBS's Educational Satellite Network," 1993).

- The Satellite Educational Resources Consortium (SERC) programming serves daily

almost 5,000 students from over 500 schools in 34 states enrolled in high school credit courses, and an additional 75,000 students participating in middle school science programs. The consortium also supports thousands of teachers, administrators, and staff with professional development programming. Sixty percent of the schools receiving SERC programming are classified as rural, 71 percent are eligible for Chapter 1 funds, and 75 percent have fewer than 1,000 students. Credit high school course offerings include precalculus, probability and statistics, calculus, physics, Advanced Placement economics, Japanese, Russian, Latin, German, and Spanish. SERC membership is open to all states. Member states are represented on the board of directors by the chief executive officer of the state public broadcasting entity and the chief state school officer.

SERC is in the process of retrofitting all its downlink sites so that they are capable of receiving compressed digital programming. It is also integrating voice mail conferencing and full Internet capability into its course design because of a recognized need for asynchronous communication among learners, teachers, and program coordinators. SERC recently entered into a five year contract with PBS for transponder space on Telstar 401, realizing $600,000 in savings per year on transponder costs by moving to digital compression, which requires less bandwidth.

- The Satellite Telecommunications Educational Programming (STEP) network is operated by the Educational Service District 101 in Spokane, Washington, and delivers programming nationwide. Fifteen K-12 student courses are offered in Japanese, Spanish, Russian, environmental science, English, workplace basics, Young Astronauts, career paths, middle school science and technology, English as a second language, marine science, and world events. All courses are interdisciplinary in their approach. In 1992-93, almost 2,000 hours of live interactive STEP programming reached almost 15,000 students in 14 states. Access to inservice programming was provided for more than 33,500 teachers. In 1992 there were more than 700 STEP downlink and cable sites. STEP estimates that equipment costs for participating schools range between $5,000 and $10,000.
- The Southern Educational Communications Association (SECA) is a membership organization with 65 public broadcasting licensee members in 20 states. SECA distributes programming, via satellite programming produced by its members, other public television entities, and independent producers, to public television stations nationwide. SECA members receive the programming for free, whereas subscribers pay an annual service fee. SECA also provides feeds of instructional programming each week and administers the National Instructional Television Satellite Schedule, which provides instructional programming to schools.
- Telecommunications Education for Advances in Mathematics and Science (TEAMS) is a service of the Los Angeles County Office of Education. TEAMS focuses on science and math classroom instruction at grades 4-6. Programs use team-teaching techniques that include the classroom teacher and the studio instructor. Professional development occurs at two levels: first, studio instructors model effective instructional strategies during student lessons; second, professional development modules for teachers precede the four-week student instructional module.

TEAMS' latest initiative is the APOLLO 2000 project, serving more than 50,000 students in grades 2-8 across the United States. The project is designed to provide programming that directly supports the National Education Goals, with courses on mathematics, science, literacy, and citizenship skills. APOLLO 2000 is using an integrated network of satellite programming, telephone, computer, and fax communication to achieve interactivity in the learning process and provide adequate support to learners and teachers.

USE OF DISTANCE-LEARNING RESOURCES

The multiple technologies described above (broadcasting, satellite, microwave, ITFS, cable, telephone, computer networking, and wireless) are being integrated in delivery systems across the country. Learners are using these systems to receive the distance-learning programs of the major service providers, in addition to locally produced classroom instruction and other educational programming. Although comprehensive data concerning the use of distance-learning resources are unavailable, our review of the literature and conversations with experts in the field at the national, state, and local levels revealed that distance learning is being used at all levels of education, from prekindergarten through adult and professional education.

Some attempts have been made to compile statistical data about the users of particular distance-learning technologies and services. For example, the cable industry reports that approximately 34.5 million students nationwide—73 percent of all K-12 students—have access in school to cable programming (Kerns, 1994). Service providers funded by Star Schools grants are estimated to serve 140,000 K-12 students in classrooms across the country (Tushnet, Bodinger-de Uriarte, Manuel, van Broekhuizen, & Millsap, 1993). One aspect of distance learning, video programming, is delivered to users in K-12 schools by a variety of means—in 1992, of the 41 percent of K-12 schools using distance learning, 45.9 percent of video programming was received by satellite dish, 34.8 percent by cable television, 9.6 percent by ITFS, 5.2 percent by fiber optics, and 4.4 percent by copper-based telephone wiring (Quality Education Data, Inc., 1992). A survey conducted in 1991 found that 80 percent of all two-year colleges and 78 percent of four-year colleges and universities anticipated using distance learning by 1994 (Brey, 1991). Almost one-third of Fortune 500 companies report using distance learning for training workers (Portway, 1994). Though confirming that distance learning is occurring nationwide, these statistics do not indicate the number of learners actually using distance-learning services, the ways in which the services are being used, or the frequency of use.

The following examples describe how some users are incorporating various technologies for distance learning produced by major providers and local institutions in K-12 education, higher education, adult education, and the workplace. In most cases, several technologies are integrated to provide complete distance-learning experiences. The descriptions are loosely categorized according to the technology that provides the last link to users.

Broadcasting

Television broadcasting is typically used for distance learning to reach learners in both homes and schools. It is a one-to-many technology that allows a broadcaster (usually an educational institution or a commercial provider) to distribute a program to many people at the same time, while allowing the learners to be located in different sites. Broadcast distance-learning programs are often called telecourses and usually involve watching a broadcast of an instructor (either live or recorded), completing exercises in a workbook, reading a textbook, and visiting a registered site to be tested. Broadcasting is usually used to reach part-time learners, many of them adults whose busy schedules do not allow them the flexibility of attending classes on a campus at a set time. For example, PBS's Adult Learning Service (ALS), one of the major providers of broadcast telecourses (broadcast locally by public television stations), serves a clientele most of whom work outside the home, are over 35 years old, and have family responsibilities. Almost 80 percent of the of ALS learners are working toward either a graduate or bachelor's degree ("Changing the Face of Higher Education," 1992).

Because the learners receiving distance learning through broadcasting consist of a largely adult population, most of the broadcasters are local stations that work with community colleges, either broadcasting telecourses produced and distributed by a service provider like ALS or broadcasting instruction from their classrooms to

on-site students. For example, Coastline Community College (CCC) in Orange County, California, broadcasts telecourses over KOCE-TV, a licensed public television station owned by CCC. The college broadcasts both telecourses produced by CCC and from service providers such as the Adult Learning Service. Their curriculum committee does extensive review of the telecourses for accreditation. The courses are mainly required introductory courses in a variety of disciplines. They offer 27 telecourses to an average 7,000 students per year, most of whom are working adults trying to return to college. CCC indicates that broadcasting is especially effective for reaching their clientele (Lucy Pascoe, CCC, personal communication, June 3, 1994).

Most broadcast telecourses attempt to provide interactivity between the student and the facilitator. The traditional method of written correspondence has all but been replaced by a variety of telecommunication technologies, ranging from voice-mail applications to group teleconferencing. The use of electronic network discussion groups to provide interactivity for broadcast telecourses is one of the most promising emerging technologies, but providing network access for distance learners remains a difficult challenge (Ted Pohrte, Dallas County, Texas, Community College District, personal communication, June 1994; Neal Sapper, Amarillo (Texas) College, personal communication, June 1994.

Some school districts are also using broadcasting to reach learners who are trying to earn their General Equivalency Diploma (GED). The Granite School District in Salt Lake City, Utah, found broadcasting to be a relatively inexpensive means for offering GED instruction. During the 1990-91 and 1991-92 school years, the school district broadcast seven courses over the local public broadcast station, KULC. The courses, licensed from various producers, ranged in cost from $400 to $1,500 per course. The courses included: (1) Here's to Your Health, (2) Introducing Biology, (3) Earth Revealed, (4) American Adventure, (5) America: The Second Century, (6) Discovering Psychology, and (7) Personal Finance and Money Management. The school district paid $3,000 each year to KULC to broadcast all seven courses for the entire school year (Joe Rickards, Granite School District, personal communication, June 1, 1994).

Radio broadcasting is being used in some areas of the country in a manner similar to telecourses. For example, Wisconsin Public Radio (WPR), one of the largest producers of audio-print courses for higher education, is working with six campus systems served by public radio station licenses to deliver the courses over the air to off-campus students (Dan Peterson, WPR, personal communication, June 1994).

Satellites

Satellite distribution of distance-learning services allows for programming to be received anywhere in the continental United States where users have the proper satellite downlink equipment. Because programming is received directly from the provider and is often used live, satellite-delivered distance learning lends itself particularly well to live interactivity among learners and teachers, approaching the level of interaction often seen in a classroom. Satellite-delivered distance learning typically is used at schools, workplaces, and community institutions where structured educational activities are occurring. It is used in very few homes because of the expense of satellite downlinks.

Distance-learning courses that are distributed live through satellite typically provide interaction between the instructor and learners through the telephone. Learners call into the studio, sometimes through a toll-free number or an audio bridge and ask questions directly to the instructor, who then responds on the air. Some satellite distance-learning providers, such as the GALAXY Classroom project, are providing their students asynchronous interaction through the use of fax and electronic mail (Lori Konopka, Turner Educational Services, Inc., personal communication, May 1994).

Typically, satellite distance learning is used by institutions at all levels of education to provide students with learning opportunities that they

otherwise would not have. For example, in 1990 the state of Kentucky was mandated by court order to rectify the inequities of its education system by using technologies such as those used for distance learning. The state has responded by installing more than 1,700 downlinks sites across Kentucky, including downlinks at every elementary, secondary, and vocational school, community college, and university campus, where students receive the same analog satellite programming from Kentucky Educational Television (KET), which uses a single transponder. Programming ranges from the K-12 level to advanced graduate-degree level. Original programming produced at the University of Kentucky and programming from major service providers, such as SERC, are distributed by KET. In the next few years, KET expects to follow PBS's move to a digitally compressed signal that will allow simultaneous distribution of six channels of programming on a single transponder. The move to compressed digital will require upgrading of all downlinks to handle the digital signal (Nofflett Williams, University of Kentucky, personal communication, June 20, 1994). PBS is currently estimating that the cost of a digital receiver (required to upgrade a downlink) will be approximately $1,800 (*Telstar 401 Update*, 1994).

Satellite distance learning is being used in a similar manner in the state of Mississippi, which has one of the nation's highest illiteracy rates and lowest percentage of high school graduates. Project LEAP (Learn, Earn, and Prosper) uses downlinks sites in elementary and secondary schools to provide job training and GED completion courses to adult learners, many of whom are single mothers receiving public assistance. The downlinks are used during the school day by K-12 students, who receive a variety of programming, including SERC, STEP, and BCSN. The LEAP adult learners have early-morning and evening classes that are transmitted live and provide interaction with the instructor through telephone calls (Ed Meek, University of Mississippi, personal communications, April 1994).

Some corporations such as Hewlett Packard use satellite distance learning to save the cost and time of transporting their workers dispersed around the world to training courses at one site. Hewlett Packard has developed an extensive satellite-delivered distance-learning network for its employees to receive job training at their places of work. Workers from more than 100 classrooms located in company sites around the globe connect to an education network, providing them with video programming from an uplink facility in California and two-way voice communications. Keypad systems in the classrooms allow students to immediately respond to instructors' questions—instructors can monitor the responses and analyze students' level of understanding. Students can also use the keypad to indicate to the instructor that they wish to ask a question. The network allows workers to upgrade their skills and knowledge without leaving their work site, which is both costly and time consuming. Hewlett Packard anticipates in the near future to deliver similar distance learning directly to workers' desks (Portway, 1994). Previously, Hewlett Packard brought all of its sales representatives together for a few days of training each time a new product was introduced, at a cost of $5 million per seminar. Since incorporating distance learning, the cost of each training session has dropped to about $80,000, a savings of over 98 percent (Perelman, 1994).

Hewlett Packard's use of satellite networks saved the company 98 percent of training costs.

Microwave

Point-to-point microwave is typically used as a transport link in an integrated delivery system; however, sometimes it is used to provide small closed-circuit networks that are connecting a limited number of sites. Because microwave is a line-of-site delivery system, each additional receive site added to the network requires the addition of another transmitter at the transmission site. Microwave is easily adapted to a two-way video link by installing a transmitter at the receive site for a return signal. This is the greatest advantage for using microwave as a "last link" delivery system.

Northern Arizona University (NAU) is using microwave to provide a two-way link between classrooms that are participating in live distance learning, where the instructor is teaching a class at

45

one site and classes at other sites are also participating. The instructor and the students at the other sites can all view one another on video monitors. NAU is producing and delivering more than 25 upper-level undergraduate and graduate courses per semester to rural community colleges around the state using point-to-point microwave for full-voice, video, and data services all on one circuit. NAU transmits an analog microwave signal, which provides broadcast-quality video, and uses two subcarriers for audio and data exchange. The classes are fully interactive, with a 52-inch television and video cameras in each participating class. The microphones in each classroom are voice activated; and the telecourse can distribute up to 150 live microphone signals at one time. All programming on the network is locally produced and is monitored by a single control-room operator, usually a student in the communications or engineering program at NAU. Internal assessment has revealed that students onsite and those participating through distance learning have comparable grades and attendance records. Professors have enthusiastically embraced the system, largely because NAU provides extensive support that adapts the technology to the needs of the instructor (Paul Neuman, NAU, personal communication, June 21, 1994).

Each broadcast-quality classroom costs between $140,000 and $170,000 to build, and the microwave transmission equipment and infrastructure costs approximately $250,000 per site. NAU has spent approximately $3 million and NTIA has contributed almost $1.5 million to build and operate the system. Before the construction of the microwave network, NAU would fly instructors around the state, often 400 or 500 miles, just to teach one course for one day. To lease a T1 data line running from Flagstaff to Yuma, NAU would have to pay $48,000 per year. The cost of using the subcarrier on the microwave network was a one-time expense of $12,000 for two T1 data modems (Paul Neuman, NAU, personal communication, June 21, 1994).

ITFS

When large numbers of users need to be served in multiple learning sites in a region, the omnidirectional nature of the ITFS microwave signal allows for the construction of a single transmitter for delivering distance learning up to about 30 miles without extending the signal. WHRO in Norfolk, Virginia, exemplifies ITFS use for both delivering services directly to users and providing links between other delivery systems such as satellite and cable.

WHRO operates four ITFS channels in Norfolk and an additional two channels in nearby Hampton, Virginia. WHRO gets its feeds by satellite, microwave, cable, and fiber from assorted providers, but the majority of its programming is produced by Old Dominion University, which maintains a fiber optic link with WHRO. WHRO delivers its signals by ITFS directly to elementary and secondary schools and to the headend cable operators for 14 community colleges, colleges, and universities. Programming includes graduate-level engineering, business, and nursing courses otherwise unavailable at the various institutions, and upper-level undergraduate courses that allow community college students to attain their bachelor's degree without leaving their campus of study. Receive sites for these distance-learning courses also include institutions in areas not in proximity of higher education institutions, such as hospitals, museums, and media centers in K-12 schools. WHRO has recently entered into a partnership with a private wireless cable company. In return for WHRO's providing the cable company with an ITFS channel that the station acquired as an educational licensee, the cable company is providing WHRO and some of the educational institutions that use its distance-learning programming with new transmission and reception equipment (John Morison, WHRO, personal communication, June 21, 1994).

One example of WHRO's impact on the region is the delivery of distance-learning programming to the K-12 school on Tangier Island, which lies in the middle of the Chesapeake Bay and is accessible only by boat and airplane. The

school was encountering difficulty retaining qualified teachers for more than one year and justifying the cost for small enrollments in certain courses. The school now uses WHRO's ITFS system (2-way) to offer its students many of the educational opportunities that students on the mainland have. The Accomack Public Schools superintendent, under whose jurisdiction Tangier Island falls, uses the ITFS system to conduct meetings with administrators and teachers on Tangiers Island without requiring expensive and time-consuming travel (John Morison, personal communication, June 21, 1994).

No reliable usage-break-down information exists on the approximately 1,500 ITFS licenses (Theodore Steinke, personal communication, June 13, 1994). ITFS is also being used to link other distance-learning technologies (Leveille, 1992), further complicating usage analysis. A 1991 report of the American Association of Community Colleges (AACC) stated, however, that 16 percent of two-year institutions and 29 percent of four-year institutions were using ITFS systems (Brey, 1991).

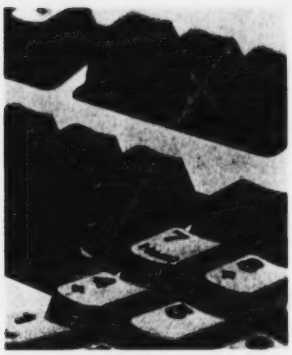
Cable

Cable television can be used both to access major service providers and to distribute local programming. Because many learners have access to cable at both school and home, cable has the ability to reach wide audiences in diverse settings with the same programming. Uses of cable delivery systems for distance learning range from viewing Cable in the Classroom documentaries, to distributing a locally produced course, to experimenting with some of the latest two-way interactive cable systems.

Students in Mason County, West Virginia, who are only a few credits short of high school graduation are using distance learning delivered by cable television to complete the coursework needed for their high school diploma over the summer. Due to budget limitations, the school district had been unable to offer these students summer school classroom instruction. An agreement was worked out with the local cable company to deliver English, biology, and history courses four days a week for two hours each day on the local cable system. The courses, produced locally by a team of teachers using inexpensive low-end equipment, provide students with the opportunity to continue with their post-high school plans without enrolling for another semester in the fall. Of the 80 students enrolled in the courses in 1993, 63 received passing grades. Mason County plans to incorporate Cable in the Classroom programs for the 1994 courses (Kerns, 1994).

Many people are using the convenience of cable television to watch educational programming and take telecourses, such as the ones developed in Mason County, in their own living rooms. Mind Extension University (ME/U), a national service provider that is carried as a basic service on 895 cable systems reaching 25.6 million households, offers a wide range of high school, undergraduate, graduate, and personal-enrichment classes. Users participating in a degree program enroll with an ME/U affiliated school. Materials that accompany each course are purchased by the user by mail order or, if available, at a local bookstore. Tests are taken at local libraries or schools where proctors registered with ME/U provide supervision. Approximately 7,000 people have enrolled in degree programs through ME/U. An estimated 40,000-50,000 people have participated in the courses, although not necessarily for credit. Because the programming is an open signal, even if a person is not registered for a course, he or she can follow along informally, although no academic credit will be received toward a degree program (Pamela Pease, Mind Extension University, personal communication, May 24, 1994, and June 28, 1994).

The Carrollton School District in Carrollton, Georgia, is actively using cable programming in its curriculum at the K-12 level. As one of the eight demonstration sites for an innovative TeleCommunications, Inc. (TCI) Education project, the district is in the process of integrating its cable network with a fiber optic data network. Working with TCI, each classroom in the school system has been linked to districtwide



cable and fiber networks that carry video and data. TCI is in the process of wiring the homes of students determined to be "at risk," allowing parents and students in these homes to receive local educational programming that is targeted directly at these families (NCTA, 1993b, pp. 6, 17). TCI is planning to offer a video service to all homes in the Carrollton School District that will allow parents to interact with their children's teachers and find out information about educational performance. Although the school district uses educational programming from service providers, it is also generating some of its own programming. Through a special agreement with Cable News Network (CNN), the school district receives a raw video feed from CNN, which is in turn edited and produced into a local news show by Carrollton High School students. The program is then sent over the cable system to the entire community. Since Carrollton School District first implemented its cable network, along with other technologies, the high school dropout rate has decreased from 28 percent to less than 5 percent. The school credits the use of telecommunications technologies as an essential component for achieving this positive step (Robert Hendrick, Carrollton School District, personal communication, June 28, 1994).

As with other educational programming, cable providers of distance learning are also attempting to incorporate interactivity into the learning experience. In an innovative combination of live cable and electronic networks, Turner Broadcasting has begun to offer live "electronic field trips." Teachers and students watch live educational programming while interacting with each other and on-site experts through toll-free phone lines and America Online discussion groups (Lori Konopka, CNN Public Relations, personal communication, May 1994).

Telephone

The telephone system is typically used for distance learning as a means for providing a voice return to an instructor who is being viewed by students through an alternative means of video delivery and as a connection to on-line computer services. For example, the Backus Elementary School in the District of Columbia is one of the many sites around the country using TEAMS's math and science programming delivered via live satellite feed. Students interact with their instructor by dialing a toll-free number during the live program. Some innovative uses of voice information services, such as voice mail, are underway around the country. Recent developments in compression and switching are allowing for the compilation of voice, video, and data signals of distance-learning programming, all on standard copper telephone lines.

Impact North Carolina: 21st Century Education is a comprehensive plan to help schools take advantage of multimedia distance-learning experiences using ISDN and the existing copper-wire telephone network. The Watagua School District in Boone, North Carolina, is using the network to provide two-way videoconferencing and data exchange among Watagua High School, two elementary schools, and Appalachian State University. Each of the four sites maintains three ISDN lines. One is connected to the file server of a local area network, using the university's ethernet backbone and providing access to on-line library resources and electronic mail. As a result, electronic communication is often used along with the videoconferencing services to provide richer learning experiences. For example, students collaborate on a project with other classrooms, using electronic mail, and present the final results of their efforts during videoconferences. Another ISDN line is connected to a multimedia workstation, allowing users to take advantage of dynamic graphic capabilities that are often incorporated into the videoconferencing presentations. The third ISDN line is connected directly to the videoconferencing equipment. This includes two viewing monitors and an overview monitor for displaying documents and objects, all coordinated using a wireless remote control (Riedl & Carroll, 1993).

Individual students and entire classrooms communicate with each other and with the university. High school students regularly develop interactive presentations for elementary students; and elementary students from the two schools collaborate on science experiments. These services are available to all teachers and students. Watagua also receives professional development programming and conferencing services from the Texas Interactive Instructional Network (TI-IN). Future plans include adding schools in six other counties to the network. Teacher training, a flexible communications system with a variety of learning options, and a designated network service coordinator have been important aspects of the technology use (Patty Blanton, Watagua High School, personal communication, June 1994; Riedl & Carroll, 1993).

Computer Networking

Students are using computer networking to access and share resources, information, and instruction across distance, creating virtual learning envoronments. Typically, computer networking is used primarily as a secondary form of interaction in support of distance-learning programming. For example, MCET's Learn NET allows learners and teachers to access support materials, exchange information, and participate in on-line activities coordinated with MCET's video programming.

Some schools are using computer networks as the hub for technology resources, providing users with the ability to incorporate multiple technologies into the learning process (including distance learning). The ACT Academy in McKinney, Texas, is a K-12 school that has installed an elaborate computer network in order to integrate distance-learning services with the other telecommunications technologies available to its learners. The ACT Academy is a demonstration school funded by a $6 million grant from the U.S. Department of Education. Its charge is to break the mold of conventional instruction using technology-based strategies that promote academic excellence. Each teacher and student in the team of 12-18-year-old students (approximately 100 students) is provided with a laptop computer. The "7-11-year-old team" (180 students) has one portable computer for every 2 students. The "5-6-year-old team" (38 students) uses fixed "docking" stations that provide access to one computer for about every 7 students. Data drops that connect to the computer network are located throughout the school—in classrooms, in hallways, and in the outdoor courtyard. Every classroom has a telephone line, and an Internet node is being established at the school. Students and staff also have access to multimedia computers, printers, CD-ROMs, laser disc players, camcorders, cable TV, on-line services, and distance-learning equipment. The curriculum is project-based and requires students to use all of the tools available to them through the network to work with other students to complete the projects.

An emerging use of computer networking for distance learning is the delivery of integrated voice, video, and data services directly to the desktop. Since 1991, Ford Motor Company has offered university-level courses to employees directly to their desktop computers. Using microwaves, fiber optics, cable, electronic keypads, and telephone links, real-time voice and data exchange is made possible between employees throughout southeastern Michigan and instructors at Wayne State University. Employees access the live, interactive classes using IBM PS/-TV units connected to their office computers, which double as TV monitors. Students hear dialogue just as they would in a classroom, watch the professor or graphic and written information on screen, and use the keypad call button to "raise" their hand. The response feature is an important part of the system; for example, within five seconds, a bar chart can be displayed showing the distribution of answers to an instructor's questions, giving an immediate sense of whether students are grasping a particular concept. After each class, student progress is monitored by the computer; and appropriate remedial lessons are developed. Participants also use telephone conferences and electronic mail as part of the coursework.

According to Ford, employees who have used this system have scored 20 percent higher on examinations than those employees who took the same courses in a traditional classroom setting. The company also found that the increased activity and regular assessment capabilities encourage better preparation, participation, and self-assessment. Among the other benefits are efficient resource use, greater accessibility to learners, and cost reduction. Although significant expenditures were necessary to provide a host computer, site controllers, and keypads, the system has proved efficient. The PS/2-TV units cost less than $500 each and are very easily moved to another desk. Transmission costs are $60 per hour. Ford estimates that most participants save more than 30 hours commuting time per class per semester (Klinck, 1993; Steele, 1993).

Wireless

Using wireless technologies to make the "last link"—to the user—is an emerging, but relatively untested, option for distance learning. PBS is working with the cellular technologies industry to provide the new Mathline service to teachers and learners via wireless communication. Mathline is a full-service interactive data, video, and voice network that plans to offer discipline-based mathematics learning services, professional development opportunities, and electronic forums. Participants in the planned wireless project will be provided with laptop computers and will receive Mathline services, via their local public television station, using cellular communications. The benefits of such projects have not yet been evaluated, but clearly have the potential to address "last-link" problems for learning sites, independent of cable or telephone wires (compiled from materials received from PBS Mathline and the Cellular Telecommunications Industry Association, June 1994).

SUMMARY

The range of distance-learning technologies and services described in this chapter shows several means for providing and receiving distance-learning services, using technologies that function singularly and in integrated systems. These descriptions enable us to better understand the available and anticipated resources for meeting the needs of learners at all levels of education—prekindergarten through graduate school. The diversity of telecommunications technologies used to deliver distance learning and the range of integration of these technologies highlight the complexities involved in developing systems. Despite increasingly rapid changes in technological developments, fluctuating price structures, and relatively limited data on the use and effectiveness of telecommunications technologies, all levels of education are moving ahead with innovative applications of these technologies for distance learning.

New challenges and opportunities for improved education have been created by recent federal education legislation and telecommunications industry initiatives. Education legislation not only calls for statewide technology plans, but provides funding support for learning technology planning and implementation. The Goals 2000: Educate America Act and the Improving America's Schools Act, which includes the Technology Education Act of 1994, provide increased funding specifically intended for technology planning and implementation. In addition to the new federal opportunities, states are providing significant amounts of funding to develop statewide infrastructure and distance-learning resources. The Public Broadcasting Service (PBS), cable companies, and telephone companies are investing in infrastructure and content programming. These initiatives provide new challenges for educators to harness the potential of telecommunications resources for the benefit of all learners and to meet the National Education Goals.

Even with these new opportunities and resources and the growing popularity of educational technology, effective distance learning is still a relatively untapped resource with enormous potential to improve learning opportunities. According to Market Data Retrieval (MDR, 1993), only 28 percent of the nation's school districts use some form of distance-learning technologies. Many barriers to its use have been successfully overcome, but many still exist, whether due to lingering past misconceptions or new challenges faced by a rapidly changing field. This chapter examines many of the significant barriers and challenges to effective distance learning and analyzes the ways in which they affect various levels of education and instruction. The issues discussed here do not draw from comprehensive case studies of distance-learning implementation. Rather, this chapter presents a sampling of issues most often noted in research literature, trade publications, and informal discussions with individuals experienced in planning and using distance learning.

INCOMPATIBILITY OF TECHNICAL SYSTEMS

Because distance learning involves an integration of technologies, issues of incompatibility are obviously significant. Increasingly, rapid changes in technology are resulting in incompatibility problems at all levels of distance learning use. The emerging role of digital compression is a good example of this problem. This technological innovation allows for much more efficient use of bandwidth and airtime, but usually involves new equipment for the user and additional transmitting complications for the provider. Some providers such as the National Technological University (NTU) and the Southern Educational Resource Consortium have made comprehensive systemwide changes. NTU has installed new units throughout its system at both origination and downlink sites. Just as is commonly done with Ku- and C-band satellite systems, services are offered in both the old and new formats. Other providers are adopting a more cautious approach because compression protocols vary and standards

Although federal education legislation and NII initiatives are providing new opportunities for distance learning, significant barriers still exist to its effective, widespread use.

have yet to be established. This particular issue is critical, because many major providers, including PBS, intend to incorporate digital compression technology. Community colleges are among the most significant users of satellite networks; for this group, the onset of digital technology presents serious cost and planning obstacles, requiring them to replace or upgrade equipment they had purchased only within the past five years (Monica Pilkey, CCSN, personal communication, December 1993).

Rapid advances are changing telecommunications at all levels, and innovations can often surpass the capabilities of the greater infrastructure. As a result, even in cases where use of distance learning has been well thought out and implemented, long-term goals can meet with incompatibility problems at the telecommunications industry level. The Watagua school district in North Carolina is one such example. Their very successful ISDN network is serving the community's learning and communication needs, but plans to extend the network to link six neighboring counties have proven difficult due to the regional phone network's insufficient signal-switching capabilities (Patty Blanton, Watagua High School, personal communication, June 1994).

INSUFFICIENT USE OF AVAILABLE RESOURCES

Many schools and businesses make little use of available resources for various reasons. On the most basic level, all delivery systems are simply not available everywhere. Though homes and businesses have long been wired for telephones, for example, schools traditionally have not; and because cable television's primary application has been news and entertainment, both schools and businesses were not initially wired. Sharing resources is an obvious option; but without regional cooperation, telecommunications resources may operate in parallel rather than in an integrated fashion. Increasingly, however, communities are beginning to organize their efforts. One of the most popular remedies for limited access to delivery systems seems to be cooperation among schools, colleges, and businesses. The CCSN notes that businesses and associations are currently developing training that uses the facilities of a local community college, approximately 85 percent of which have some access to satellite networks (Monica Pilkey, CCSN, personal communication, December 1993).

Some technologies have evolved haphazardly over many years, prompting distance-learning users to reevaluate functions for underestimated resources. Telephone, for example, which was originally intended to provide only voice communication, now provides video and data delivery as well. Ford Motor Company, whose use of innovative keypad response systems to provide interactivity has been very successful, is nevertheless looking to transfer this response function to computers and telephones. This "return" to the more ubiquitous telephone system will allow their employees to take courses at home, make the services available to nonemployees, and also alleviate the problem of acquiring new keypad hardware (Steele, 1993).

Another common barrier to using resources is an inability to incorporate distance learning into existing instruction. Scheduling within traditional school organization is a significant challenge for K-12 distance-learning use. The rigidity of the school year and school day are often formidable barriers (Tushnet, Bodinger-de Uriarte, Manuel, van Broekhuizen, & Millsap, 1993). Because satellite-delivered programs often do not mesh exactly with the school schedules, such conflicts are difficult to resolve (Barker, 1992). Broadcast television and cable providers are also tied to schedules that conflict with school schedules. Research on distance learning, in fact, often cites issues of time and scheduling as the most significant obstacle (Honey & Henriquez, 1993). Although videotaping courses has been a helpful option, increasing use of interactivity and more collaborative activities surrounding distance-learning programming may diminish the usefulness of delayed viewing.

52

COSTS OF TECHNOLOGY

Distance-learning costs involve both initial expenditures and ongoing programming and operation costs. For universities and large corporations, which are more likely to establish custom-made telecommunications systems, costs are greater. VSAT networks, commonly used by large corporations for whom maintaining private systems is important, can cost up to $12,000 per site to install (Carl Girod, PBS, personal communication, June 10, 1994). Most K-12 schools and small businesses are likely to subscribe to an existing telecommunications system, rather than construct an entire ITFS, microwave, fiber optic, or satellite network. Even so, initial expenses can be quite an investment. A 1991 survey of community colleges found that, among the reasons listed for not having a plan for distance learning by 1994, "too expensive to start" and "state provides insufficient funds for distance learning" were the most often cited. Almost one-half of two-year institutions noted the barrier of start-up costs. By comparison, less than 10 percent cited opposition by faculty, administrators, or board of trustees as significant barriers (Brey, 1991).

One of the most universally accessible telecommunication networks is the telephone system, although schools are less likely to have adequate phone lines than are businesses. Even when the network is established and functioning, distance-learning applications can still be quite costly. For example, audio conferencing—which is relatively low cost compared to satellite networks—can cost from $50 to $400 for each speaker phone and $1,000 to $3,000 per port for bridge equipment. Ongoing costs include maintenance and per-minute telephone charges for long-distance calls. Audiographics systems additionally require graphic tablets, scanners, facsimile machines, and separate telephone lines for data. Audiographics equipment costs can range from $6,000 to $13,000 per school (Barker, 1992).

Several sources provide financial, technical, and equipment support for distance learning, including RBOCs, cable companies, and private foundations. Several large federal programs have also underwritten telecommunications technology acquisitions and services for schools, including the U.S. Department of Education's STAR Schools program, the U.S. Department of Commerce's NTIA grant programs, and programs of the Rural Electrification Administration fund. Other private and federal programs provide limited support for curriculum development, special programming, technical assistance, and related research (for a complete list, see Krebs, 1993).

In recent years, states and local communities have underwritten distance education systems by issuing bonds to cover construction costs; passing legislation to install equipment such as satellite dishes in schools; providing state grants for local projects; and in one instance, levying special taxes on videotape rentals to support distance-learning costs (U.S. Congress, OTA, 1989). In many cases of ITFS, fiber optic networks, or satellite programs, cooperative agreements between school systems and commercial businesses or telecommunications service providers have overcome cost barriers. The trend for ITFS use, for example, is for educational institutions to lease valuable microwave frequencies to commercial wireless cable companies in exchange for equipment and technical assistance.

REGULATORY BARRIERS

All delivery systems for distance-learning services are regulated by state or federal agencies. Two primary industries, the telephone companies and the cable companies, have made commitments to providing a national broadband communications network to schools. Issues surrounding the development of networks—including what types of services will be offered by what industries, what fees can be required of whom, and to whom will access be required—are still being discussed, negotiated, and legislated. The current pending legislation will require the FCC to develop the requirements that can establish universal, affordable rates for education. Distance-learning issues of delivery service integration are of primary concern (Gooler, 1991).

For distance learning that uses these telecommunication networks as a means of delivering nationally produced educational programming and instruction, there are additional concerns about copyrights and viewing restrictions. According to a report from the International Telecommunications Council (ITC):

> Current conventions of marketing television courses may be a barrier to their widest use. The course elements and the rights to distribute them are often sold separately. For instance, television programs for most courses are licensed both as a full-credit class and as a set of video programs to be used individually in classrooms. Sometimes the rights to use a course on different distribution systems are marketed independently. These practices confuse the marketplace and may discourage institutions from purchasing or using the courses to their fullest advantage (Brock, 1991, p. 7).

As with all telecommunications applications, copyright and intellectual property rights will continue to be problems for distance learning. "Fair use" definitions have not yet been clearly defined for emerging distance-learning technologies (Brillson, 1993).

TRAINING PEOPLE TO USE LEARNING TECHNOLOGIES

Training is a major issue, particularly for K-12 education, where distance learning is being incorporated by working teachers. Training is now being addressed at all levels, from the local school to the state to the service provider. Schools and systems that make use of distance learning have done an inadequate job of preparing teachers to use the technology well. A case study conducted by OTA indicated that 64 percent of the teachers involved in tele-teaching had not received prior training on the distance-learning systems used, even though many aspects of teaching and learning have to be rethought for distance learning to work well. The role of the on-site facilitator is also critical. In many programs, this person is responsible for operating the receiving equipment, monitoring student behavior, evaluating homework and classroom assignments, and supervising testing. Nonetheless, many projects provide no systematic training or support to these important personnel (U.S. Congress, OTA, 1989).

According to the American Association of Colleges for Teacher Education (AACTE), only about 20 percent of teacher-training programs offer coursework incorporating current learning technologies. Preservice and inservice training programs should incorporate technology throughout teachers' education, instructing teachers with the same tools they themselves will be expected to use (Portway & Lane, 1992). States are taking the lead in addressing training issues. The State of Alabama, in its attempts to ensure the effective use of learning technologies, established a Teacher Education Scholarship program, which intends that all participants will be able to use and integrate telecommunications, ranging from Internet to satellite programming (McFadden & Johnson, 1993). Tennessee has incorporated teacher training as a prerequisite to technology funding, and most state technology plans include technology training as a primary goal. Many of the STAR Schools program providers routinely incorporate training and professional development activities into their offerings.

COURSE ACCREDITATION

Issues of accreditation for distance-learning courses present new challenges to traditional education. The extent and specifics of these factors vary among K-12 education, higher education, and worker training. Elementary and middle-grade classes do not typically involve formal coursework, nor do most worker training efforts. In higher education, distance learning is most often provided in the form of complete courses that are either originated at and used by the accredited institution, or are nationally distributed courses that go through extensive formal accreditation procedures by the college or university

using the services (compiled from materials received from PBS Adult Learning Service, Coast Community Colleges, and others). In general, accreditation issues are most significant at the high school level, where state-regulated graduation requirements must be fulfilled by specifically approved curricula. A national accreditation system for distance learning has been suggested as one solution to this problem (Schlosser & Anderson, 1994). In addition, implementation of voluntary national content standards called for by Goals 2000 should help define common elements for distance-learning providers.

The focus on experimental learning, individualization, and interdisciplinary content creates many possibilities for creative use of distance learning to enrich traditional instruction, but also opens many points of disputes about the conditions under which distance learning is appropriate and effective. These broad goals and fewer boundaries on content make the K-12 grades particularly challenging for situations in which distance learning is used to enrich classroom instruction. Informal, less structured programming has been a proven factor in improving learning (Tressel, 1994); but such programming often lacks financial and institutional support. Some researchers have called for a reformed curriculum as a crucial factor for incorporating learning technology, suggesting that "to discuss effectively the importance of integrating education technology into the curriculum, it is essential that the traditional focus of curriculum be reframed to accommodate the reform and restructured outlook for schools" (Center for Educational Leadership and Technology [CELT], 1994, p. 67).

COST AND ACCOUNTING SYSTEMS

The challenge in elementary and secondary education is further exacerbated by the accounting systems of most public school systems. In contrast to most colleges and universities, which have cost-accounting systems that relate to specific departments (i.e., the English Department, the Biology Department, etc.), public schools do accrual accounting, which does not distinguish among various content areas of instruction. Therefore, distance learning often becomes an add-on cost that cannot be equated with traditional costs. Consequently, cost-effectiveness studies are hard to define and measure. Public school cost accounting is merged together, so that it is difficult to analyze costs of different activities, including distance learning. Funding for distance learning, however, almost always includes cost accountability measures (Schlosser & Anderson, 1994). This requirement will increasingly necessitate better cost-accounting systems, which will, in turn, facilitate distance-learning implementation.

Space and personnel costs are also associated with distance learning. Although the distance-learning provider will usually provide the content expertise, in most schools there must be an adult facilitator and, in some instances, a certified teacher. Cost-accounting systems must be employed that give distance-learning providers a per-pupil, per-hour cost that includes a share of the amortized cost of equipment over a lifetime for the equipment, operating and maintenance costs, on-site personnel costs, and housing costs, as well as the actual cost of the distance-learning course and the support services required.

The business community tends to have a clearer sense of cost effectiveness with regards to training resources. A distance learner earning a master's degree on site at her workplace is more cost effective for the company than an employee sent off to college for a period of time. A Federal Aviation Authority radar operator who learns the latest applications of the new radar system on distance-learning workstations at the airport is more cost effective than is one sent away for prolonged instruction. Use of distance learning in the military has proven to be much more cost effective than traditional on-site instruction (Redding & Fletcher, 1993). Colleges and universities—because they charge tuition—are also more likely to have cost-accounting systems that differentiate among different instructional efforts than are public schools.

INSTITUTIONAL STRUCTURES

All education is local in nature, whether it is in the public school classroom, the shop floor, or the local community college. K-12 education, however, involves an enormous bureaucracy in which state and local authorities maintain control over public school activities. Planning for distance-learning use is often complicated as a result.

One example of this complexity is the critical issue of teacher certification. Often, a distance-learning teacher of a high school course that is used in many different states must be certified in each state in which viewing students reside (Schlosser & Anderson, 1994). For higher education, certification is less of an issue because instructors are usually working professors whose credentials are more likely to be universally accepted (Holt, 1992). In the workplace, teacher certification is not as relevant, although qualification of instructors is certainly a universal issue.

Although distance learning has been used for decades, it is still fundamentally different from the traditional classroom-based instruction that remains the model of American education. Many challenges are faced by distance-learning providers who attempt to extend classroom walls. Perhaps most critical, the current organizational structure of both educational institutions and businesses often prohibits effective planning for nontraditional methods. Distance learning involves a combination of expertise in technology, content, and instructional design; and few institutions offer opportunities to bring this expertise together (Schlosser & Anderson, 1994). This lack of "distance-learning-friendly" institutional structures has often been blamed for inadequate planning, a major barrier to successful implementation of distance learning (U.S. Department of Education, 1993). As technologies become more integrated, content and instructional design issues become more complicated. Good distance-learning programs, therefore, will increasingly require effective communication among the various players.

State governments have begun to take increasing control of planning for distance learning, bringing together the necessary diversity of expertise (Schlosser & Anderson, 1994). This positive step not only can help coordinate activities, but help avoid incompatible or duplicate efforts. State technology plans increasingly include business and industry in collaborations with schools, universities, and community organizations. State organizations are also helping to accommodate issues of local autonomy. The Massachusetts Corporation for Educational Telecommunication's STAR Schools program is providing a menu of programming and technology from which local districts can choose services that best meet their particular needs (Schlosser & Anderson, 1994).

PROGRAMMING QUALITY

Among the many distance-learning delivery systems, a large portion of services are video based. Modern distance learning has its roots in televised lectures. As these services evolved to include better audio and video quality and more interactivity, the role of an on-screen teacher has become better understood as a unique characteristic of distance learning. High-quality, distance-learning programming depends on good on-screen instructors. An effective on-screen presence requires different skills from those of traditional teaching. In the workplace, although formal certification is usually unnecessary, the quality of instruction is recognized as important but often not appropriately designed for the target audience. One researcher noted: "Too frequently, the training function is conducted by a content expert who is not an adult education facilitator" (Portway & Lane, 1992, p. 288). Experts in the field at all levels agree that the abilities of the on-screen instructor are crucial and that such methods require particular skills (Minninger, 1993). An on-screen instructor must be organized, be able to pace the lesson effectively, and recognize what materials are appropriate for video. For programs that take fuller advantage of the medium by using taped video inserts or computer graphics, the instructor must be able to create a cohesive presentation.

Roles vary greatly, depending on the program format. In some cases, the instructor is the producer, director, and floor crew all in one. More high-production value formats may use a full studio facility and support staff, requiring only that the instructor work well in a studio setting (Holt, 1992). The qualities of an excellent distance-learning instructor extend well beyond a firm grasp of subject matter and an engaging style.

AWARENESS AND ACCEPTANCE

The myth that distance learning is a second-rate alternative to traditional instruction is, unfortunately, still prevalent in all sectors of education and training (Lane, 1993; Steele, 1993). At the elementary and secondary levels, lack of acceptance of distance learning has been an issue partly because of the circumstances under which it was introduced into American schools. Schools turned to distance education most often when qualified teachers were in short supply in critical content areas, when teachers could not be attracted to distant or rural areas, and when the number of students needing or interested in particular courses was too small to support a teacher's salary (U.S. Congress, OTA, 1989). Thus, distance learning often is seen as an alternative to hiring teachers and, in some circles, was promoted as a more cost effective way of providing instruction in certain subject areas, raising concerns among educators about how large-scale use of distance learning would affect levels of teacher employment and responsibility. Such concerns still fuel resistance in schools.

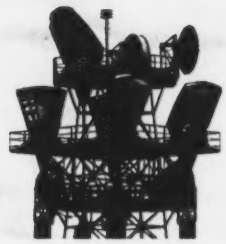
For K-12 schools in particular, a "not developed here" syndrome often prohibits ready acceptance of distance-learning resources. This may be a deciding factor for school districts that choose to establish "closed" ITFS or satellite networks, in which local resources are shared within a few districts or counties. The ability to maintain local control of the instructor, programming, and scheduling has been cited by some as a significant advantage to using audiographics-based systems instead of nationally distributed satellite programming (Barker, 1992). Staff working on the STAR Schools TEAMS program, which serves thousands of students nationwide, cite this as a persistent barrier, noting the need for a local feeling of ownership and participation in the program (Don Lake and Frank Withrow, personal communication, August 1, 1994). In this respect, some regional or local networks for K-12 distance learning are similar to private networks used by many businesses, who may prefer to maintain stricter control of industry-specific course content (Portway & Lane, 1992).

For some educators, distance learning is equated with television, which, despite research to the contrary, has been persistently criticized as having a negative influence on learning. This belief results in an underestimation of video-based instruction as a learning tool, particularly for children. Thus, distance learning has been used most often for more self-motivated learners. These attitudes are rapidly changing, and funding programs such as the federal government's STAR Schools program are bringing distance learning to K-12 students and underserved populations (Schlosser & Anderson, 1994). In the workplace, business television networks have acquired a proven track record of providing high-quality, cost-effective training (Lane, 1993).

Limited awareness of new developments also may contribute to negative impressions of distance learning among educators not familiar with the varied instructional and technological formats available today. Many educators and students formed impressions of distance learning when it was little more than broadcasts of an instructor addressing a regular classroom, employing one-way video and audio, poor quality monitors, no interactivity, and delayed evaluative feedback for students. The reality of today's distance-learning programs provides a wide array of interactive options and feedback systems that are increasingly easier to use, easier to watch, and less expensive. More important, they provide the ability to tailor instruction and allow students to construct their own knowledge through different modes of learning.

CONCLUSION

Much of this chapter has focused on barriers to effective distance-learning use in K-12 education. Although distance learning may offer the means of transforming K-12 education in ways that broaden access to education and support critical elements of current reform efforts, challenges here may be more numerous and more daunting than in other education settings. Clearly, the potential for distance learning to upgrade the nation's work force and ensure lifelong learning is equally important and also relatively untapped. Many of the barriers faced by users of distance learning, such as lack of acceptance and instructor qualification, are universal issues. Some barriers faced by K-12 education, such as cost accounting and budgeting structures, have been addressed by higher education and business. As the field evolves to integrate more resources, and collaborative efforts increase, distance-learning users at all levels can learn from the ways in which other organizations have overcome obstacles to successfully meet learning needs.



58

An interconnection of computer networks, telecommunications services, and applications, the National Information Infrastructure can open up new vistas and profoundly change much of American life, not by the fact that it exists but by the way it is used.

Ronald H. Brown, U.S. Secretary of Commerce, May 3, 1994

During the past decade, we have seen a wondrous explosion of technological innovation that has begun to change the way that we live and work. But these developments will no doubt pale in comparison with the changes that are likely to occur within our society in the next five years. In particular, technology will change the ways in which we educate our students . . . how teaching and learning will take place.

Richard Riley, U.S. Secretary of Education, May 9, 1994

The challenges of the information age require lifelong learning for all citizens; and, as we have seen in this report, distance learning has an essential role in meeting this need. This report has described the wide array of distance-learning resources available in schools, colleges, homes, and workplaces. The examples represent both traditional and innovative applications of telecommunications technology. Important advances in using distance learning have been made, but significant barriers continue to prevent the widespread use of effective distance learning. The following recommendations have been developed, within the nation's plans for the National Information Infrastructure (NII), to overcome these barriers and realize full use of distance learning to achieve the National Education Goals. These recommendations are nationwide in scope and, therefore, general rather than specific to particular states, localities, institutions, or businesses. They encompass an essential principle for the development of distance learning; namely, that such development requires combined private and public action through federal, state, and local education agencies; private industry; and distance-learning service providers.

Recommendation 1: Education agencies at all levels must support the development and use of distance-learning resources to achieve the National Education Goals.

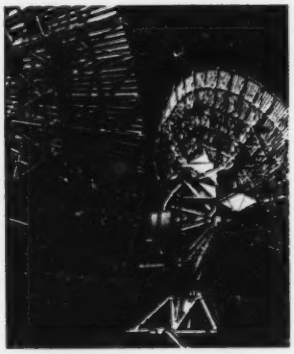
America's National Education Goals set, for the first time, bold expectations for student achievement, from school readiness to adult literacy. Content and student performance standards, assessment strategies, and professional development for teachers provide the building blocks for achieving these Goals. Distance-learning resources are essential for the provision of student opportunities to achieve the Goals.

Recommendation 2: Education agencies at all levels must ensure equitable access to distance-learning resources to increase the opportunity for all citizens to learn.

The capacity to use information technologies is an economic imperative for the work force of the 21st century. Attainment of this capacity by some, but not all, of our citizens is widening the gaps of opportunity for employment and civic and earning power. Distance-learning technologies have the capacity to reach underserved learners; they promise to further increase lifelong

59

learning opportunities. To provide potential for all citizens, state and federal education agencies must plan for distance-learning resources that overcome inequities of access to technology outside education institutions.



Recommendation 3: The telecommunications industry, distance-learning service providers, and regulatory agencies must support and develop distance-learning delivery systems and information networks that are compatible, interoperable, and cost effective.

A major barrier to increased use of distance learning is the lack of connections among platforms and delivery systems. It is essential that standards of interoperability be established for these technologies to continue to be used for education and training. The developing NII combines public and private resources. Business and industry must work together to create mutual systems that enable the users to function across platforms, ensuring all educational environments convenient access to distance-learning technologies. The increasing potential for integration of telecommunication technologies must be at the center of distance-learning plans.

Recommendation 4: Federal and state governments, together with local communities, educational institutions, the telecommunications industry, and business and industry, should promote public/private partnerships for distance learning and support regional and statewide applications of distance learning as part of an integrated national resource.

Cooperation is essential to achieve cost effectiveness through economy of scale across regions and states, to reach larger constituencies, and to encourage better education and training at all levels. The development of distance-learning systems must be comprehensive and serve schools, colleges, museums, libraries, community facilities, and hospitals in efficient ways with high-quality programs provided by diverse providers. Multiple use of distance-learning technologies should be designed for the widest range of users possible. This will yield cost savings and greater accessibility.

Recommendation 5: State and federal regulatory agencies must develop policies that ensure affordable rates for the educational uses of telecommunications resources. Regulatory agencies having appropriate responsibilities should ensure availability of universal telecommunications services for all levels of lifelong learning and maintain reasonable fair-use copyright guidelines for instructional materials used in distance learning.

State and federal regulatory agencies should develop policies and procedures for telecommunications that favor education and training opportunities. Regulatory standards across the nation must provide for affordable educational uses of the telecommunication networks that deliver distance learning. Intellectual property rights are increasingly important issues for distance learning, and evolving regulations should maintain the concept of fair use for educational purposes.

Recommendation 6: Federal and state agencies, in cooperation with the private sector, should develop new resources for investment and capital development for distance learning. Support from federal agencies must be coordinated to provide efficient and effective funding uses.

High-quality distance-learning resources require significant new investments. Private sector and public resources must be coordinated to ensure a sound mix of support for research, development, and distribution of distance-learning products. Equally important is the need to coordinate federal funding capacities toward higher priorities and leverage efforts for system expansion.

Recommendation 7: Professional development programs for educators and administrators should rely increasingly on distance learning and include technical training for the use of distance learning in formal education programs.

It is obvious, but important to report, that

effective use of distance learning requires appropriate training. Such training should be comprehensive and designed so that select staff will become distance-learning instructors, as well as users of distance-learning resources, to enable a pyramid growth effect. Most educational practice now is organized around textbooks and classroom presentations. Learning technology applications must enable teachers and instructors to handle telecommunications technologies as the educational tools of the information age.

Recommendation 8: State education agencies must improve course accreditation procedures to advance the use of distance learning and other alternative education offerings.

The delivery of quality learning to locations where most needed is a primary objective of distance learning. This service does not and should not stop at state boundaries. Unfortunately, state-by-state course-accreditation practices are a significant barrier to the effective use of distance learning for high school graduation requirements. Bilateral and multilateral or regional agreements among states must evolve to accommodate new teaching and learning techniques and provide appropriate quality assurance.

Recommendation 9: Providers of distance learning must develop cost-accounting standards that provide accurate information on unit-of-instruction costs and instructional effectiveness assessments for distance learning.

Most school systems, colleges, and even business training programs lack cost-accounting structures that allow for accurate analyses of the comparative impact of innovative learning and teaching models. Accounting standards should be adopted that accommodate alternative educational resources such as distance learning. Appropriate unit cost data are needed to make evaluations of the instructional cost-effectiveness. Cost-effectiveness evaluation of distance learning requires both appropriate cost-accounting structures and precise assessments of learning effectiveness.

Recommendation 10: Education institution authorities planning to use or expand distance learning must take special actions to create organizational environments for undertaking the values and limits of the service for the desired effects to be realized.

Collaboration among technical experts, educators, instructional design specialists, and resource managers is critical for effective planning and implementation of distance learning. Creating environments in formal education and the workplace that bring together such teams of individuals is a key factor in overcoming outmoded practices. Here again, the point is obvious; but the task must not be underestimated and must be explicitly planned and budgeted.

Recommendation 11: Distance-learning providers and users must join forces to strengthen distance-learning content requirements and instructional formats.

State education agencies are actively developing and implementing comprehensive content and student performance standards to meet the National Education Goals. Distance-learning service providers must use these standards and change products for schools and workplaces. Distance-learning providers have a special advantage in incorporating new standards into their courses and instruction and, thereby, lead the reforms. They must capitalize on this advantage. State and local education agencies, teachers and instructors, and individual home-learners are more likely to use distance-learning services that meet learning goals.

Recommendation 12: Local, state, and national authorities should undertake awareness and outreach activities to inform educators, business and industry, and the public of the value and importance of distance learning to achieve the National Education Goals.

A significant barrier to widespread use of distance-learning technologies is a lack of awareness and acceptance of distance learning as an effective and valuable option for education and

training. Educators and the general public must have an understanding of not only the role of distance learning in improved education, but the ways in which it can be a cost-effective learning resource. The importance of distance learning to basic education, school-to-work transition, worker training, individually tailored learning, and enhanced opportunities for lifelong learning for all citizens must be made clear. Public discussion of issues related to the developing NII provide a timely context for distance-learning awareness efforts.

Summary

These recommendations are based on assumptions that the technologies involved with distance learning are on a course of convergence, and that this convergence relates to wired and wireless broadband digital voice, data, and video transmissions. Effective development calls for new structures that take advantage of the developing technologies and allows a full range of freedom in developing competitive learning technologies. This new highway of information will significantly increase the potential for distance learning to meet the National Education Goals. The federal government, therefore, should work in partnership with state and local entities, private sector communications industries, institutions of higher education, and the public to ensure that all citizens have access to the broad array of resources that are a part of the nation's treasure. Widespread access to distance-learning resources is an important facet of the opportunity for lifelong learning that is an integral part of these initiatives and a necessity for the 21st century workplace.

The effective use of distance learning to meet the National Education Goals requires combined private and public action through federal, state, and local education agencies; private industry; and distance-learning service providers.

We hope that this report and its recommendations will encourage the growth of distance learning in this country. Distance learning has evolved from simple correspondence and one-way television broadcasts to an almost unimaginable array of interactive technologies and applications, many of which have been described in this report. However, significant barriers must be overcome if distance learning's potential is to be fully realized. As these recommendations make clear, greater acceptance and understanding of learning technologies, increased cooperation, and shared use of facilities are all important to the cost-effective, widespread use of distance learning. As distance learning becomes a basic resource available to all learners, it can help guarantee all Americans lifelong opportunities for education and training. The development of distance learning is essential to achieve our National Education Goals.

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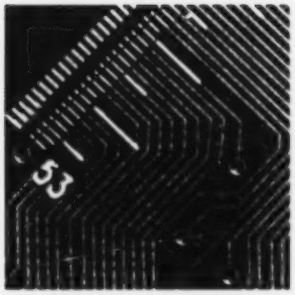

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AACC	American Association of Community Colleges
AACTE	American Association of Colleges for Teacher Education
ADSL	asymmetric digital subscriber line
AG*SAT	Agricultural Satellite Corporation
ALS	Adult Learning Service of PBS
ALSS	Adult Learning Satellite Service of PBS
ASTD	American Society for Training and Development
ASU	Appalachian State University
ATV	advanced television
BCSN	Black College Satellite Network
CCC	Coastline Community College in Orange County, California
CCSN	Community College Satellite Network
CCSSO	Council of Chief State School Officers
CELT	Center for Educational Leadership and Technology
CETN	Central Educational Telecommunications Network
CNN	Cable News Network
CTN	Community Telecommunications Network—Detroit, Michigan
DBS	Direct Broadcast Satellite
DoDDS	Department of Defense Dependents Schools
EFF	Electronic Frontier Foundation
ETV	Educational Television
FCC	Federal Communications Commission
GED	General Equivalency Diploma
HBCU	historically black colleges and universities
HDSL	high-bit-rate digital subscriber line
HDTV	High-definition television
HEC	Higher Education Consortium for Distance Learning—Massachusetts
IEA	International Educational Assessment
IPS	Indianapolis Public Schools
IREAD	Indianapolis Regional Economic/Academic Development—Indiana
ISDN	integrated services digital network
ITC	International Telecommunications Council
ITFS	Instructional Television Fixed Service
KET	Kentucky Educational Television
LAN	local area network
LEAP	Project LEAP—Mississippi
LPTV	Low power television
MCET	Massachusetts Corporation for Educational Telecommunications
MDR	Market Data Retrieval
ME/U	Mind Extension University
NAU	Northern Arizona University
NCC-TET	National Coordinating Committee for Technology in Education and Training
NCTA	National Cable Television Association
NCTM	National Council of Teachers of Mathematics
NII	National Information Infrastructure
NIST	National Institute of Standards and Technology

NTIA	National Telecommunications and Information Administration
NTU	National Technological University
NYNEX	New York/New England telecommunications system
OERI	Office of Education Research and Improvement
PBS	Public Broadcasting Service
PCS	personal communications services
PTFP	Public Telecommunications Facilities Program
PTV	public television
PUC	Public Utility or Service Commission
RBOCS	Regional Bell Operating Companies
RETN	Regional Educational Television Network—Vermont
SCANS	Secretary of Labor's Commission on Achieving Necessary Skills
SCOLA	Satellite Communications for Learning Association
SECA	Southern Educational Communications Association
SERC	Satellite Educational Resource Consortium
STEP	Satellite Telecommunications Educational Programming—Washington State
SWRL	Southwest Regional Educational Laboratory
TCI	TeleCommunications, Inc.
TEAMS	Telecommunications Education for Advances in Mathematics and Science—Los Angeles
TI-IN	Texas Interactive Instructional Network
TIIAP	Telecommunications and Information Infrastructure Assistance Program
TLC	The Learning Community—Massachusetts
TOC	Technical Operating Center of CTN
USDLA	United States Distance Learning Association
USEN	U.S. Educational Network
USSB	United States Satellite Broadcasting
VCR	videocassette recorder
VSAT	Very Small Aperture Terminals
WLAN	wireless local area networks
WPR	Wisconsin Public Radio

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70

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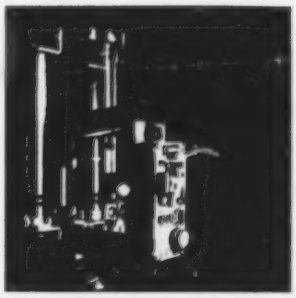

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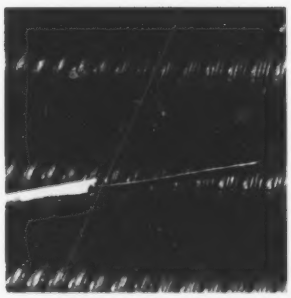

74

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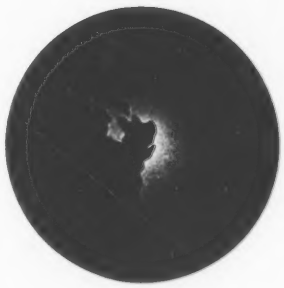

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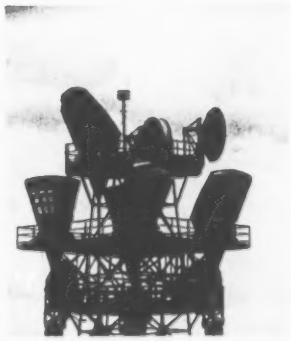

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88

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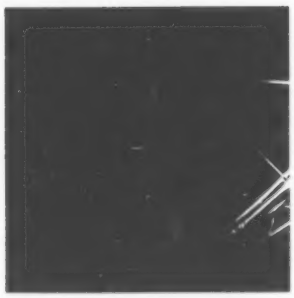
89



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90

Audio bridge. Electronic device used for conferencing that connects and controls multiple telephone lines, allowing many callers to be connected simultaneously. Audio bridges can be used for both voice and data applications.

Broadband capacity. The ability of some communication technologies to use bandwidths expansive enough to transmit voice, data, and video signals simultaneously.

Cable headend. Regional electronic control center that receives and retransmits television signals to receiving sites in a cable system.

Cellular technology. A wireless communication technology operating at a specific range of microwave frequencies, most often used for mobile, point-to-point telephony.

Coaxial cable. Insulated wire cable able to carry multiple broadband signals, commonly used in cable television networks.

Digital compression. A technique that allows broader bandwidth information to be "squeezed" into a smaller bandwidth for easier transmission. Special hardware is required at both the sending and receiving points to encode and compress and decode and decompress the signal.

Direct broadcast satellites (DBS). This technology allows users to receive high-resolution, compact-disc-quality signals directly from a satellite using a small (18-inch) receiving dish.

Distance learning. The delivery of voice, video, and text to a learner, from one location to another, using some form of telecommunications technology.

Fiber optics. The use of hair's-width glass wire that manipulates laser light rather than electricity to carry signals. Fiber optic wire has the capacity to carry far more information at less cost than copper wire or coaxial cable. It permits two-way audio, data, and video transmission and has high capacity and speed, easily expandable channel capacity, and a high-quality signal.

HDTV. High-definition television. Developing television system that offers higher resolution than standard television and compact-disc-quality stereo sound.

Internet. The growing international network of computer networks that uses the same protocol (language) for transmitting digital information from one computer to another, allowing users to access on-line information and communicate with other users individually or in groups.

Interoperability. The ability of a communications system to operate effectively between platforms, with a variety of hardware and software.

ISDN. Integrated Services Digital Network. International standard for dial-up that provide a common architecture for transmission of digital information over a public telephone network. ISDN equipment can transmit voice and compressed video and data over copper wire lines.

ITFS. Instructional Television Fixed Service. The specific band of microwave frequencies set aside by the FCC for educational use. ITFS systems use these frequencies to broadcast audio and video signals within a limited range (usually less than 50 miles).

Local area networks (LANs). A high-speed data communications system that is completely contained within a single office or campus environment.

Low-power television (LPTV). Broadcast technology similar to commercial or public television but limited in broadcast coverage area by its low power signal.

Microwave technology. The portion of the electromagnetic spectrum, from approximately 1,000 MHz to 100,000 MHz, capable of focusing concentrated signals over long distances. These frequencies are used for a variety of point-to-point or omnidirectional communications, from terrestrial-based systems such as ITFS to satellite systems.

Modem. Electronic device that converts digital computer signals into analog format for data transmission, used to link computers to telephone networks.

National Education Goals. Eight goals for education, approved by the nation's governors in 1989 and enacted by the U.S. Congress in 1994, which set guidelines for educational achieve-

ment, from school readiness to adult literacy and parent involvement.

NII. National Information Infrastructure. A seamless web of communications networks, including computers, televisions, telephones, and satellites. (From Vice President Gore's comments of September 13, 1994.)

PCS. Personal Communication Services. A developing wireless communications technology operating at a specific range of microwave frequency that allows for voice, video, and data.

Telecommunications. The branch of science relating to the transmission of information, including voice, video, and data.

Transponder. Device used on communication satellites to amplify and repeat voice, video, or data signals from a terrestrial uplink site to a terrestrial downlink site.

Very Small Aperture Terminals (VSAT). Small earth stations with small (4-6-ft diameter) satellite dishes programmed to receive specific frequencies, often used to distribute specific educational services or used by businesses to provide private satellite networks.